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This will be the only issue of California Tufgrass Culture published in 1983. The reason for this single issue is inadequate funding for the printing and distribution of newsletters such as "CTC." UC Cooperative Extension will be making policy decisions shortly concerning newsletters. Thereafter, we will attempt to return to the quarterly format that characterized this publication for so many years.

Victor A. Gibeault

Problems and Solutions to Maintaining Sand Greens and Playing Fields

William B. David[1]

Many sport fields and golf greens have been constructed using sand as the growing medium. The terms *sand fields* and sand golf greens mean different things to different people. At the University of California, we have been advocating a simplified construction system using unamended sand. The range of sands suitable for such a system is quite specific, and has been thoroughly discussed in other papers. For many reasons, we have given up trying to develop a sand-organic or a sand-organic-soil mix and have concentrated on the pure sand concept. Many of the so-called sand fields are mixes consisting of 75 to 90 percent sand. The problems and solutions, covered partially in this paper, pertain to our recommended sand concept and system.

Managing a highly used turf grown on a sand medium generally does not present problems. It does present a challenge for some turf managers: How do you adjust sound turf management practices so as to maximize the potential of the sand medium? Sand as a growing medium for high-use athletic areas is not a substitute for professional turf management skills, but even with poor management, most sand fields afford consistently satisfactory playing conditions. They have the added advantage of quick conversion back to excellent field condition with skillful management.

It is hard to beat a loam or sandy loam soil as a turf-growing medium. If a turf area has limited use and if it is not used during periods of poor climatic conditions, there is no need to consider sand as its growing medium. Also, one should not expect a sand medium to afford the same playing conditions as a well-managed soil field or golf green under ideal climatic conditions. Just as artificial turfs are different, so are natural turf fields grown on sand. A properly installed sand field or golf green will never have a saturated surface. It will not compact as will other soils and soil mixes. It will not vary from a soft, mushy, or muddy surface to brick-hard depending on the moisture content of the growing media. But its excellent drainage characteristics can cause problems if we don't manage the sand medium differently than we manage a soil or soil mix.

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Irrigation

Once a solid turf stand is established, the actual water use of turf (evapotranspiration) will be the same for soil mixes as for pure sand. The frequency of application may vary, since some soils or soil mixes may hold more water than the *right sand* and require fewer irrigations. Because of restricted root zone due to compaction common to many old golf greens and soil football fields, irrigation frequency may be less frequent for the sand green or field. Over-irrigation and the resultant leaching can produce problems. The turf manager must apply only the water needed, and cannot rely on surface ponding of water to tell him it is time to turn off the water. All too often we irrigate by flooding the area with a sprinkler system which applies water faster than it moves into the soil. With a sand, we cannot rely on surface flooding to indicate coverage, so we must have a well-designed irrigation system which applies water uniformly. Do not blame the poor performance of a sand green on a poor irrigation system or poor water management.

Nutrition

Careful attention must be given to fertilization practices for new sand fields and golf greens. It is not a problem, but a challenge. The excellent drainage characteristic of the right sand means it can be excessively leached. During periods of high rainfall, frequent application of soluble fertilizers or use of coated or slow-release fertilier must be properly programmed-the right program for a soil or soil mix may not be the right one for sands. As a turf matures, organic matter is naturally added to the sand. Under proper management, a natural balance is developed: nutrients are less subject to leaching, but good drainage characteristics are still maintained. Aerating and topdressing the sand plugs back into the green help to maintain this proper balance.

For many turf managers, fertilization of a sand medium is less of a problem than addition of high levels of nutrients to compacted soils. Some turf managers experience problems in establishment of turf on sands, relating to irrigation and fertility. The l/4 to 1/2 inch of sand will dry out very rapidly due to surface evaporation. This means that light, very frequent irrigation is required to maintain a moist surface for good seed germination. Two to three light irrigations per day might well maintain a moist soil surface, while a sand green may require eight to twelve very light applications.

If at each irrigation more water is applied than is needed to replace that lost by evaporation, excessive leaching can occur. Even under the best of irrigation practices, frequent light applications of nitrogen and sulfur may be needed to ensure fast establishment. In most new sand fields and greens in California ammonium sulfate has been the fertilizer used.

Some sources of sand and irrigation water have produced both very low (below 4.5) and very high (above 8.5) pH conditions. While rarely encountered in California, these are special conditions which require special fertilization programs. Our present research program on fertility management indicates that well-established sand greens may be better managed at lower rates of most all nutrients than is the standard practice for most older golf greens.

Mowing

For large sport fields where mowing heights range between 1 and 3 inches, mowing frequency should be governed by the rate of growth and the playing conditions desired. Where possible, the turf should be mowed so as to remove less than one-half of the leaf blade at each mowing. Clippings need not be removed. Sand fields can be mowed at any time without causing compaction or damaging the soil structure. Rapid removal of excess surface moisture greatly increases the time available for maintenance practices.

Problems have occurred on putting greens due to mowing too close and too often. A proper cushion of thatch must be established and maintained, so since sand medium greens are typically firmer than greens on other media, they should be mowed at no less than l/4 inch no more often than every other day during the first year. Once a good 1/2-inch thatch cushion has been established, frequency and height of cut may be changed. Sand greens are uniformly firm, and are faster than most other greens. Their mowing program should be based on the rate of grass growth and putting speed, not on what may be a standard practice for other greens.

Aerification, Verticutting and Topdressing

Sand sport fields and golf greens need to be aerified primarily to maintain a proper balance of thatch and to aid in the mixing and breakdown of thatch. Aerification with l/2-inch tines is done during the early summer. The sand plugs are topdressed back into the turf. Depending on thatch buildup one to three aerifications are recommended one month apart. Aerification during early summer reduces *Poa* invasion and obviates any sealing of the surface due to excess thatch. Following aerification, the turf will need to be lightly irrigated two to three times during the day until the holes recover. Field experience has shown that up to a 6-ton roller can be used with the right sand. Rolling the golf green following aerification quickly restores putting quality and speed.

Verticutting should be evaluated carefully before it is tried on a sand-media turf. Verticutters set for old greens tend to cut too deeply into sand putting greens. The verticutter should be used only if a very grainy turf condition develops. Controlling thatch is better done through an aerification and topdressing program. Topdressing golf greens has been covered in other papers, but it is well to remember that the amount of sand applied should be less than l/l6 inch at any one time. Aerification holes need not be filled with sand as when trying to put a new surface onto an old soil green. Frequent light topdressing and use of l/2-inch tines followed by rolling will maintain the firm, true surface.

Sport fields may become severely worn and require heavy topdressing in order to restore a uniform grade. In most cases the right sand can be topdressed at rates of l/2-inch thickness. These playing fields will need to be aerified with 3/4-inch tines frequently enough to maintain a good thatch balance. Drag matting the sand plugs back into the turf and subsequent rolling will assist in thatch control, maintain a proper grade, and heal divots.

Wear Resistance

A sand medium does not improve the ability of any given grass species to resist wear. Maintenance practices to recover from wear can be performed any time the turf is not frozen or under snow cover. Severely worn turf on sand fields can still present a playable field if kept moist and rolled, and if there is no mud or free standing water to further reduce its playability.

In California, it generally takes 8 to 12 months to establish a strong sod which will resist wear. All too often, new sport fields are put into play less than 5 months after seeding. Playing 65 football games between September 15 and November 15 will wipe out any turf regardless of its growing medium. Starting a good program of recovery immediately following the last game of the season produces a stronger turf for the following year.

One or two points presented in this paper might give the turf manager a clue as to where to look for a solution to problems he or she might be encountering. For a sports field or a golf green, successful management of a sand medium turf area depends primarily on how well the turf manager understands what is known and how well he or she can apply this knowledge to the particular situation.

Presentation given at the Western Canada Turfgrass Conference-February 27-March 1, 1983.

Toxicity of Selected Insecticides to White Grub (Cyclocephala spp.) in Southern California Kentucky Bluegrass Plantings

W. R. Bowed

Among the most harmful pests to affect the nearly 1.4 million acres of established turfgrass plantings in California is soil-inhabiting white grub, which feeds on grass roots. Where grub infestations are heavy, grass roots may be entirely eaten away and turf can be rolled back like a carpet. Aboveground symptoms are browning and dying of grass in localized spots or in large, irregularly shaped areas. In addition, turfgrass managers must often do battle with skunks and other animals that tear up turf in search of the grubs as food.

White grubs are the larvae of scarab beetles, sometimes called May beetles or June beetles. Several Cyclocephala species of white grubs have been found to infest California turfgrass, but only one, *Cyclocephala hirta,* has been identified as a cause of major damage in Kentucky bluegrass plantings.

The white larvae or grubs can be up to 35 mm long when fully grown. They have three pairs of legs and are C-shaped when at rest, with many folds and wrinkles in the front half of their bodies. Their bodies' rear end is slightly larger in diameter and may be bluish or blackish. Their life cycle is 1 year. The destructive feeding activities of white grubs begin in July and last through September.

After feeding they go into a resting stage and overwinter as larvae in the soil. Pupation occurs in the spring, and the adult beetles emerge from the turfgrass in late May and June. The adult beetles are then often seen around lights at night. They are hard shelled, and vary in color from tan to brown and in length from 9 mm to 12 mm. After mating, females burrow back into the soil to lay eggs for a new life cycle.

The loss of the effective insecticide chlordane generated extensive field research to find alternatives. Most candidate chemicals selected as possible control substitutes were organophosphates with short residual characteristics. These also were susceptible to breakdown by hydrolysis or temperature. Four chemicals-Diazinon (diazinon), Dursban (chlorpyrifos), Turcam (bendiocarb), and Dylox (trychlorfan)-are currently registered for use in California as topical applications for white grub control, but experience has shown that their effectiveness has been inconsistent.

In 1980 and 198 1, three of the above materials and several new chemicals were repeatedly tested on a golf course near Temecula and in two separate trials on a golf course near Victorville. Granular applications were made using a shaker container, applying the granules evenly in two directions. The golf course sprinkler system provided irrigation immediately after treatment for an average of 0.34 inch over 45 minutes per plot. Nightly automatic sprinkler irrigations occurred thereafter. Field conditions at time of treatment were as follows: 1) the presence of mature *Cyclocephalu* larvae; 2) turf-Kentucky bluegrass, thatch- l/2 inch; 3) soil-moist, sandy; 4) weather-sunny, 85° to 100° F. In some trials, results were poor or unsatisfactory (Tables 1 and 2). The results varied between treatment dates and geographical area.

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Table 1. Total No. White Grubs (Cyclocephaia) per Twelve 1-Ft^2 Samples Found in Posttreatment Counts in High Desert, 1981

		Treatment date			
		Aug. 5		Aug. 26	
	Lb AIA	4 Wks	8 Wks	4wks	8Wks
Oftenol 5G	1.0	80 b	19 b	-	-
Oftenol 5G	2.0	60 b	24 b	44 a	9 a
Isofenphos 5G	2.0	86 b	7 a	-	-
Dioxathion 30EC	5.25	165 d	73 d	36 a	13 a
Diazinon 14G	5.45	94 b	43 c	83 b	21 b
Trichlorfon 80SP	8.0	107 c	49 c	81 b	23 b
RE-27644 I0G	2.0	112 c	25 b	-	-
RE-27644 I0G	4.0	123 c	52 c	-	-
Untreated	-	171 d	54 c	70 b	28 b

Significance = 5 percent (Chi Square)

Table 2. Total No. White Grubs (Cyclocephaia) per Twelve 1-Ft^2 Samples Found in Posttreatment Counts in Low Desert, 1981

		Tratment date			
		July 24		Aug. 14	
	Lb AIA	4 Wks	8 Wks	4 Wks	8 Wks
Oftenol 5G	I.0	37 c	24 b	70 c	29 a
Oftenol 5G	2.0	16 a	7a	16 a	16 a
Isofenphos 5G	2.0	48 c	20 b	-	-
Dioxathion 30EC	5.25	43 c	9 a	63 b	22 a
Diazinon I4G	5.45	30 b	7 a	55 b	23 a
Trichlorfon 80SP	8.0	55 c	33 c	79 c	44 b
RE-27644 I0G	2.0	26 b	I0 a	-	-
RE-27644 I0G	4.0	27 b	I5 b	-	-
Untreated	-	3 a	5 a	60 b	44 b

Significance = 5 precent(Chi Square).

Although soil and water pH were similar in all trials (7.2 to 7.6 pH), irrigation amounts were variable, and may have affected the efficacy of control (this supposition is in the process of analysis). During the dry, hot summer months from mid-July through September, measured irrigation rates averaged 0.4 inch of water per night, with a range of 3.1 to 5.0 depending upon daily temperatures.

The data in the tables, however, indicate that the organophosphate Oftanol (= Amaze, or isofenphos) provided near-consistent control of the grubs. Information provided from experimental trials conducted in other states shows that it is less susceptible to breakdown than currently used materials, and therefore has longer residual properties.

Greenbug: A Potential Turf Pest

W. R. Bowed

Professional turfgrass managers should carefully check established plantings of Kentucky bluegrass for infestations of a light green aphid commonly called greenbug and scientifically known as *Schizuphis gruminum* (Rondani).

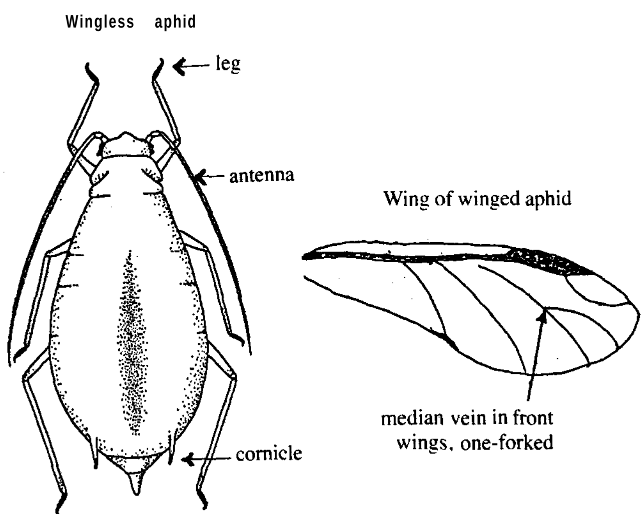
History

As early as 1907, greenbug damage was reported on bluegrass lawns in Washington, D.C. Greenbug has long been a pest of small grains and forage grasses in the Midwest. In June 1968 it was first recorded in California, infesting sorghum in the Imperial Valley and subsequently in the San Joaquin Valley. More recently it has demonstrated its ability to live on California varieties of barley, oats, and wheat, and also on Johnsongrass and sudangrass. To date, it has caused economic injury only to commercially grown wheat (seedling stages).

In January 198 1 aphids were collected from an established planting of Kentucky bluegrass on a golf course near Victorville, California. The infestation was first noticed by Dr. Harry Niemczyk, Extension Turfgrass Entomologist from the University of Ohio, who was visiting California. We collected the aphids, and they were confirmed to be specimens of the greenbug. Its characteristic symptoms of feeding injury were quite evident in areas of bluegrass shaded by trees. From three to ten greenbugs could be found lined up along the midrib of a grass blade.

Description

The greenbug is a soft-bodied aphid about I/ 16 inch long. It is straw to pale green in color and has a characteristic darker green stripe down its back. The greenbug's antennae and leg tips are black. The pair of comicles, or "tailpipes," protruding from the rear of the aphid are the same color as its body, and point inward at their tips. The comicle tips are black.



GREENBUG

Damage

Like other aphids, the greenbug pierces plant tissue with needle-like mouthparts to suck plant sap. It also injects a toxic secretion into the leaf blades which causes a reddish orange color around the feeding site. The effects of its feeding can seriously weaken the plant. Injured turfgrass areas on lawns, when viewed from the street, for example, may appear light yellowish orange or brown, as if they lack proper irrigation or fertilization. Usually the damage occurs in shaded areas, but turfgrass injury may spread into sunny areas.

Discussion

Much information about the life history of the greenbug has recently been developed by entomologists in the Midwest. However, knowledge of its biology on bluegrass in California needs to be developed in case this insect becomes an economic

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pest on the West Coast. At present, limited investigations are being made in California to determine its distribution and its ability to cause destructive damage to bluegrass plantings.

Persons responsible for turfgrass management who suspect they may have an aphid problem should contact their local farm advisor's office. Collected aphid specimens, preferably both winged and wingless, can be sent to Extension Entomologist, Department of Entomology, University of California, Riverside, California 9252 1 for identification.

Control

It is possible that the greenbug will never become a serious problem in California bluegrass plantings. Their numbers are often reduced by natural enemies. Tiny parasitic wasps kill them, and they are fed upon by lacewing larvae and by adults and larvae of ladybird beetles. However, should chemical control become necessary, a spray application of acephate (Orthene) is reportedly excellent for greenbug control, and it has a national label for greenbug control on turf.

San Francisco Bay Area Golf Course Agronomic Survey: Summary of Results

Larry Costello and M. Ali Harivandi[1]

An agronomic survey of golf courses in the San Francisco Bay Area was conducted in the spring of 1982. Bay Area counties surveyed included Alameda, Contra Costa, Marin, San Francisco, San Mateo, and Santa Clara. The objectives of this survey were:

1. To serve as an update on current maintenance practices at Bay Area golf courses
2. To determine the extent of variation in maintenance practices among golf courses in this area
3. To develop an overview of research and education needs in golf course maintenance

Survey questionnaires were sent to 65 golf course superintendents. The following report is based on information received from 42 superintendents who responded. Information was requested in the following areas.

1. Course description
2. Turf maintenance practices
3. Turf pest control
4. Tree maintenance practices

It should be noted that the results of this survey are not meant to be used as guidelines for golf course maintenance. Values presented are averages or ranges for 42 golf courses. Each course is, more or less, agronomically different from the others, and maintenance programs must be appropriate for the specific conditions which exist at each course. The survey results are meant to be used by superintendents, greens committees, and park directors to evaluate their maintenance practices and compare them with an average program for the area. Practices that differ significantly from the average might be reassessed with regard to need and merit.

[1]Farm Advisor, San Mateo and San Francisco counties; and Farm Advisor, Alameda, Santa Clara, and Contra Costa counties, respectively.

Course Description

Of the 42 courses responding to the survey, 22 are private, 13 are public, and the remaining 7 arc municipal. The courses range in age from 2 to 87 years, the average age being 39 years. Most (35) are 18-hole courses, 3 are 9-hole, 2 are 27-hole, and 2 are 36-hole. From the championship tees, course length (18-hole courses only) ranges from a low of 5,500 yards to a high of 7,156 yards, the average being 6,481 yards. From the men's tees, the shortest course is 5,500 yards, while the longest is 6,800 yards, and the average is 6,204 yards.

Play. The number of rounds of golf played annually at individual courses varies considerably, from a low of 16,120 to a high of 100,000 rounds. Average play is 53,840 rounds per year. Not surprisingly, play is much greater at municipal and public courses than at private clubs.

Size. Courses range in size from 42 acres to 202 acres, with an average of 100 acres. An average 100-acre course consists of 62 acres of fairways, 33 acres of roughs, 2.7 acres of greens, and 2.3 acres of tees.

Turfgrass species. 'Seaside' creeping bentgrass *(Agrostis palustris* Huds.) and annual bluegrass *(Poa annua* L.) are reported as the predominant turf species in greens. 'Penncross' creeping bentgrass is reported to a much lesser extent. On tees, 'Seaside' creeping bentgrass, Kentucky bluegrass (Poa *pratensis* L.), and perennial ryegrass *(Loliumperenne* L.) are most frequently named. Combinations of Kentucky bluegrass, perennial ryegrass, and creeping bentgrass are the most common grasses on fairways. Bermudagrasses *(Cynodon* spp.) and annual bluegrass are also reported present on fairways. Roughs host a variety of turf species including Kentucky bluegrass, perenniual ryegrass bermudagrasses, annual bluegrass, and tall fescue *(Festuca arundinacea* Schreb.).

Greens. Greens ranged in size from 3,000 to 7,000 square feet, with 4,750 square feet being the average. Most greens (45 percent) are soil based, while others are built on either pure sand (17 percent) or a mixture of sand and organic matter (38 percent). Eight courses reported having only sand and organic matter greens, seven have only soil-based greens, and four have only pure sand greens. Most courses. however, have combination greens: built partly on soil, partly on soil and organic matter, and the rest on pure sand.

Sand traps. Considerable variation exists among courses in number and size of sand traps: one course has only four traps while another has 109. On the average there are 50 traps per course. The smallest trap is 200 square feet, while the size of the largest is 3,000 square feet. It is interesting to note that the course that has the greatest number of traps also has the largest ones.

Mats, carts, and cart paths. Two courses reported mats on some of their tees. Over half of the courses (25) have cart paths from all tees to greens, 11 have no paths, and 6 have paths on only some holes. Only a few courses require the use of carts by all players; most make carts optional.

Personnel. Crew size for 18-hole courses ranges from two to twelve, including the superintendent. An average crew has eight workers. Eleven courses reported having union crews.

Affiliations. Exactly half of the 42 responding superintendents are members of the Golf Course Superintendents Association of Northern California, 15 are members of the Golf Course Superintendents Association of America, and 14 are members of the Northern California Turfgrass Council.

Turf Maintenance Practices

Irrigation. Irrigation system age ranged from 1 to 69 years, with an average of 16 years. Thirty-two courses are operating with automatic irrigation systems, eight with manual, and two with combined manual and automatic systems. Only two courses use computerized irrigation systems. Sources of water used for irrigation include irrigation canals, wells, city water, and reservoirs. Only four courses use treated sewage effluent water at this time. Estimated total annual water use ranges from 20 to 168 million gallons, averaging 77 million gallons per course per year. Response to the question of quantity of annual water use was surprisingly small-only 23 responded-and in some cases responses seemed inaccurate. In light of increasing concerns over water resource use and water availability, it is essential that superintendents pay closer attention to how much water they use. Apart from the issue of water conservation and the financial aspect of water use, almost all other maintenance programs are ultimately affected by the amount of water applied to the soil.

All of the courses surveyed water their greens, tees, and fairways on a regular basis. Thirty-two courses irrigate their roughs regularly, three irrigate them on an irregular basis, and seven never irrigate roughs. Twelve of the courses use wetting agents in their irrigation programs. None, however, incorporates pesticides into its irrigation water.

Fertilization. Since nitrogen is the most frequently needed nutrient in the Bay Area (phosphorus, potassium, and trace elements are usually well supplied by native soils), nitrogen application was the major aspect of fertilization investigated by the survey. San Francisco Bay Area golf courses use an average of 10 pounds nitrogen per 1,000 square feet per year on greens, 7.5 pounds per 1,000 square feet per year on tees, 105 pounds per acre per year on fairways, and 26 pounds per acre per year on roughs. Other elements applied frequently to greens, besides phosphorus and potassium, are sulfur, magnesium, and, to a much greater extent, iron.

Mowing. Greens are mowed to a height ranging from l/8 inch to 9/32 inch with an average of 3/16 inch. The average height of the cut for tees is l/2 inch, for fairways 3/4 inch, and for roughs 1 l/2 inches. Although the entire course is mowed throughout the year, frequency differs between summer and winter. The average frequency of summer mowing is six times for greens, two and one-half times for tees, twice for fairways. and once for roughs. In contrast, the winter weekly mowing frequency drops to four and one-half times for greens, twice for tees, one and one-half times a week for fairways, and once every two weeks for roughs.

Aeration (coring). On the average, golf greens are aerated three and one-half times a year. The figure is two and one-half times for tees, twice per year for fairways, and once per year for roughs. Almost three-fourths of the superintendents surveyed topdress their greens after each coring. None topdresses fairways or roughs, but half topdress tees after each coring.

Topdressing (exclusive of aeration). Greens are topdressed, on the average, four and one-half times, and tees one and one-half times per year. Fairways and roughs are not topdressed. Pure sand is the primary material used for the topdressing of tees and greens. Sand plus organic material and pure organic material are used occasionally for topdressing.

Verticutting. No verticutting of tees, fairways, or roughs was reported. Greens, however, are verticut to improve grain on an average of seven times per year. Very few superintendents reported that they verticut for dethatching purposes. Those who did reported they do it only as needed.

Soil amending. Lime and gypsum are the only amendments used. Almost three-fourths of the golf courses apply lime to their greens on a regular basis. Half of them apply lime to tees, and one-fourth apply it to fairways and roughs on a regular basis.

Gypsum is applied at a lower rate than lime. One-half of the courses surveyed apply gypsum to their greens regularly. Fifteen apply gypsum to tees, fairways, and roughs on a regular basis.

Overseeding. Half of the courses overseed their greens on a regular basis and fifteen courses practice tee and fairway overseeding regularly. Only three reported regular overseeding of roughs. Major turfgrasses used for overseeding greens are 'Seaside' and 'Penncross' creeping bentgrass. 'Emerald' creeping bentgrass is also used for overseeding greens but to a much lesser extent. Tees and fairways are primarily overseeded with Kentucky bluegrass, perennial ryegrass and 'Seaside' creeping bentgrass.

Turf Pest Control

Weeds. Very little preemergence control of weeds in greens, tees, fairways, and roughs was reported. Postemergence herbicides are used once or twice a year on tees, fairways, and roughs, but rarely on greens. The principal broadleaf weeds are (in order of decreasing occurrence) English daisy, clover, buckhom plantain, purslane, chickweed, dandelion, soliva, oxalis, knotweed, and curly dock. Crabgrass, Bermudagrass, annual bluegrass, dallisgrass, and kikuyugrass are the most common grassy weeds.

A wide variety of herbicides is used for controlling broadleef weeds, but most are either single formulations or combinations of 2,4-D, dicamba, and MCPP (mecoprop). Glyphosate is frequently used for nonselective weed control. Bensulide, DCPA, and benefin were listed when preemergence materials were being used.

Diseases. Disease management is the most common and most troublesome operation in golf course pest control programs. Disease control is primarily practiced on greens, where fungicides are applied from two to fifteen times a year. Diseases most commonly mentioned are pythium blight, fusarium blight, helminthosporium leafspot, dollar spot, brown patch, fusarium patch, and fairy ring. Over 20 fungicides were named as being used to treat these diseases.

Insects. Insect control is not as great a concern as is disease control. Most courses reported that they treat their greens approximately twice a year with diazinon to control cutworms, sod webworms, armyworms, and white grubs. Insect control on tees, fairways, and roughs is only occasionally practiced.

Other pest problems. A host of pest problems other than weeds, diseases, and insects were reported. By far the most common problem is rodent infestation; almost every survey respondent named gophers or moles as a major pest. Birds most commonly named included coots, blackbirds, and robins. Wildlife pests included ground squirrels, skunks, racoons, and deer. Nematodes were not mentioned as pests, but have subsequently been found to be a problem in annual bluegrass greens at several courses. Miscellaneous pests included golfers, residents, children, joggers, cats, dogs, and cows.

Tree Maintenance Practices

About 60 percent of the courses reported having annual tree maintenance programs which include trimming, pest control, and new planting. Litter, limbreak, and shallow rooting were noted as major tree problems, while shading and root intrusion into greens, tees, and fairways were mentioned as principal tree-turf problems.

Partial Summary of Results*

	Low	Average	High
Course description			
Age of course (yr)	2	39.4	87
Length (yd)			
Championship	5,500	6,481	7,156
Men's	5,500	6,204	6,800
Number of rounds per year	16,120	53,840	100,000
Acreage			
Fairways	30	62	100
Roughs	10	33	93
Tees	1.0	2.3	5
Greens	1.0	2.4	4
Total	42	100	202
Avg. size of greens (sq ft)	3,000	4,750	7,000
Sand traps			
Total number	4	50	109
Average size (sq ft)	200	800	2,000
Mowing			
Average height (in)			
Greens	1/8	3/16	9/32
Tees	1/4	1/2	3/4
Fairways	1/2	3/4	1
Roughs	1-1/4	1-1/2	2
Irrigation			
Age of system (yr)	1	16	60
Annual water use (million gal)	20	77	168
Fertilizer			
Total nitrogen applied			
Greens (lb nitrogen/ 1000 sq ft/yr)	6	10	30
Tees (lb nitrogen/ 1000 sq ft/yr)	4	7.5	22
Fairways (lb nitrogen/A/yr)	4.3	105	258
Roughs	0	26	193
Pest control			
Fungicide use (frequency/yr)			
Greens	2	8	15
Insecticide use (frequency/yr)			
Greens	0	2	4
Herbicide use** (frequency/yr)			
Greens	0	0.15	1
Tees	0	1	4
Fairways	1	2	4
Roughs	0	1	4

*Figures are given for survey categories which can be expressed as ranges (i.e., low, average, and high values). Ranges are for 18-hole courses only.
**Post-emergence broadleaf control only.

Fertilizing Seashore Paspalum

M. Ali Harivandi and Victor A. Gibeault[1]

Seashore paspalum *(Paspalum vaginatum Swartz.)* is a perennial warm-season grass believed to be native to tropical and subtropical regions of North and South America. Because of its high salinity tolerance, it often forms extensive colonies on seacoasts and in brackish sands. It is found from North Carolina to Florida and Texas, and south to Argentina, Australia, New Zealand, and the tropics of the Eastern Hemisphere.

Within the past 10 years, two vegetatively selected seashore paspalum cultivars from Australian mother plants have been introduced to California. The two cultivars 'Futurf' and 'Adalayd' (also sold as 'Excalibre') were grown in southern California and show considerable promise as turf for highly saline sites. Although seashore paspalum cultivars are not comparable to conventional turfgrasses such as Kentucky bluegrass and perennial ryegrass in over-all quality, they do possess qualities important in establishing turf on problem sites such as saline areas. Of the two cultivars, only 'Adalayd' or 'Excalibre' is currently sold in California; 'Futurf' has reportedly become popular as a salt-tolerant turfgrass in coastal regions of Texas and Florida.

Research at the University of California South Coast Field Station during the past 5 years indicates that seashore paspalum has high tolerance to drought, high temperature, diseases, and wear as well as to salinity. It shows medium tolerance to close mowing and shade. Establishment is slow, however, and the grass will not tolerate subfreezing temperatures for extended periods. Where the average temperature in winter drops below 55°F, the grass enters dormancy. In genera1 , it has a longer dormant period than hybrid bermuda

In 1978,the two seashore paspalum cultivars were planted (stolonized) at the University of California Deciduous Fruit Station in San Jose to evaluate their performance and quality in the Central Coast and Northern California environment. Following are the results of a study to evaluate effects of fertility on turf quality and dormancy.

The two cultivars had been established for 3 years when the experiment began in February 1981. The sward was divided into 5 ft x 5 ft plots in a randomized complete block design, and each plot received fertilizer on a monthly basis from February through November. The rate and source of nutrients used for each plot in this experiment are summarized in Table 1.

During the course of the experiment, plots were mowed to a height of 1 inch with a reel mower, and clippings were returned. Plots were watered twice a week at a rate of 85 percent Evapo-Transpiration (E.T.) calculated from a Class A aboveground evaporation pan installed adjacent to the plots. No dethatching or aerification was practiced.

Table 1. Rate and Source of Nutrients Applied to Seashore Paspalum Plots*

Treatment	N	P_2O_5	K_2O	Source
	lb/1000 ft^2/mo			
A			·	Check**
B	0.5		·	A.N.
C	1.0		·	A.N.
D	·	0.5	·	T.S.
E	·		0.5	P.C.
F	1	0.5	·	A.N., T.S.
G	1		0.5	A.N.. P.C.
H	1	0.5	0.5	A.N.. T.S.. P.C.

* Fertilizer applied monthly from February through November.
**No fertilizer applied.
A. N. Ammonium nitrate
T. S. -Triple superphosphate
P.C. -Potassium chloride

Plots were rated monthly for turf quality (color, density) on a scale of 1 to 10 with 10 being the darkest and the densest turf and 1 being dormant and/or chlorotic grass with low density. Any plot receiving a score of 6 or above is considered acceptable turf. Monthly ratings and results of statistical analysis are summarized in Table 2. Soil and air temperature data during the course of study are summarized in Table 3, and the analysis of a composite soil sample taken from the plots at the start of the experiment appears in Table 4.

The two cultivars broke dormancy in late February, and plot response to fertilizer was apparent in March. As indicated in Table 2, neither of the two cultivars produced acceptable turf without fertilizer or with phosphorus (P) or potassium (K) alone. In fact, statistical analysis showed a highly significant difference in quality between plots receiving at least 0.5 pound nitrogen (N) per 1,000 square feet per month and those receiving no N at all (Table 2). However, there was no significant difference in quality between plots receiving at least 0.5 pound N per 1,000 square feet per month; similarly. among plots receiving no N there was no significant difference in quality. Results were similar for both cultivars.

All plots receiving at least 0.5 pound N per 1,000 square feet per month, whether or not P and/or K was added, produced acceptable turf. Apparently, the amounts of phosphorus and potassium already present in the soil (Table 4) were enough to satisfy the needs of the two cultivars, and additional P and K did not affect either turf quality or length of dormancy. There was no difference in turf quality between plots receiving 1 pound N per 1,000 square feet per month. This was true for both cuftivars.

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Table 2. Quality Ratings for Seashore Paspalum Cultivars at Varying Levels of Fertility*

'Adalavd'

Treatment	F	M	A	M	J	J	A	S	0	N	D	Mean	Statistical Significance**
C	3.8	6.0	7.2	9.2	9.5	9.5	9.7	9.2	7.2	6.7	2.7	7.4	
G	3.7	6.2	6.2	9.0	9.2	9.0	9.2	9.5	8.2	7.7	3.0	7.3	
F	2.8	6.5	7.5	8.5	8.5	9.5	9.0	9.7	7.7	7.7	1.7	7.2	
H	3.7	5.1	7.0	8.5	9.2	9.7	10.0	9.2	8.2	7.5	2.7	7.2	
B	3.8	5.2	6.5	8.0	8.7	9.5	9.2	9.2	7.2	7.0	1.7	6.7	
E	1.6	3.5	3.7	4.0	5.5	5.7	6.0	6.5	6.2	5.5	2.0	4.9	
D	1.8	3.0	3.2	3.5	5.7	6.0	6.2	6.2	6.0	5.5	2.0	4.6	
A	1.6	2.5	3.0	3.7	5.2	6.0	6.2	6.7	6.5	5.7	2.0	4.3	

'Futurf'

Treatment	F	M	A	M	J	J	A	S	0	N	D	Mean	Statistical Significance**
C	4.5	6.2	7.2	8.0	8.7	9.0	9.0	7.7	7.0	6.7	3.5	7.2	
G	4.1	6.5	6.7	7.5	8.0	8.5	8.7	7.5	7.0	6.5	2.5	6.6	
F	5.0	7.0	7.0	7.5	8.0	7.7	8.5	7.2	7.0	6.5	3.0	7.1	
H	4.7	7.5	7.5	8.0	8.2	8.0	8.7	8.0	7.2	7.0	2.7	6.9	
B	4.1	6.5	7.0	7.2	7.5	7.7	8.0	7.2	6.7	6.2	2.7	6.2	
E	2.7	4.0	3.7	2.7	3.7	3.7	3.2	6.2	6.2	5.7	2.0	3.9	
D	2.8	3.7	3.0	2.5	3.0	3.2	3.2	5.5	6.2	5.7	2.2	3.7	
A	2.6	4.2	3.7	2.7	3.2	3.7	3.2	6.0	6.2	5.7	1.7	3.9	

* Monthly quality rating values are means of 4 reps, based on turf color and density, on a scale of I- IO. 10 being the darkest and densest turf.

**Statistical significance is based on the Duncan Multiple Range test at IQ. Treatment means connected by one line are not significantly different; those not connected by one line are significantly different from each other.

All plots showed improvement in quality as the year advanced, with plots receiving N reaching their peak in quality during July, August, and September and those not receiving N. although always inferior to the former, reaching their peak in quality during September, October, and November (Table 2).

From September through November, plots not receiving N produced acceptable turf, although it was much inferior to the turf of plots receiving N. All plots showed signs of dormancy during November, and all were completely dormant by early December.

The data in Table 1 suggest that addition of N may accelerate the breaking of dormancy in spring and postpone its initiation in winter. However, nondormancy by itself is not enough to justify the expense of N application, and the general quality of turf (measured by color and density) kept nondormant by N fertilization is not high. Therefore, the somewhat shorter period of dormancy attainable by application of N does not seem to warrant the time and money normally involved in fertilization.

Table 3. Monthly Air and Soil Temperatures at Deciduous Fruit Field Station, San Jose, California- 1981

	Air			Soil*		
Month	Max.**	Min.**	Avg.†	Max.**	Min.**	Avg.t
J	73	37	54.8	46	39	42.4
F	78	36	57.2	49	40	45.2
M	77	43	57. I	49	42	47.2
A	79	42	64.7	57	48	51.2
M	91	46	65.2	60	52	55.6
J	102	53	75.5	64	59	61.7
J	I02	53	71.4	64	59	61.6
A	96	52	70.2	63	59	60.9
S	90	52	69.2	62	56	58.8
0	91	44	64. I	56	50	52.4
N	81	42	58.6	52	46	50.0
D	65	39	55.9	47	44	45.6
Annual	102	36	63.6	64	39	52.7

* Soil temperature calculated at 5 inches below surface.

**Max. and min. are highest and lowest figures for the month.

† Avg. values are the means of all daily max. and min. temperature readings for the month.

Table 4. Analysis of Composite Soil Sample* from Seashore Paspalum Plot**

				Nutrient Content						
Texture	pH	SAR	Salts (mmhos/cm)	NO_3-N	P	K	B	Ca	Mg	Na
				(ppm)					(me/1)	
Clay loam	5.9	1	1 .38	45	68	635	0.21	6	5.2	2.6

* Taken to a depth of 5 in.
**Analysis done by UCCE Agricultural Laboratory. Davis.

The results of this experiment also suggest that, of the two cultivars, 'Adalayd' ('Excalibre') is superior at any level of fertilization.

It was also noted that plots receiving N were invaded by bermudagrass ('Tifway') which was transferred from an adjacent plot by mower. Plots equally close to bermudagrass but receiving no N were not invaded, suggesting that at high fertility levels and where salinity is not a factor seashore paspalum cannot compete with hybrid bermudagrass. In comparison to a stand of 'Tifway' bermudagrass grown adjacent to the study site and maintained similarly, seashore paspalum has a longer dormancy period (up to 4 months), lighter green color, and lower density. It is, however, less thatchy and does not grow as aggressively.

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Cost of Golf Course Maintenance-Palm Springs California 1982

John Van Dam, Etaferahu Takele, and Victor A. Gibeault [1]

The Coachella Valley in California has the greatest concentration of golf courses in the world. Over 40 golf courses can be found within the boundaries of several small desert cities. These prestigious courses have been developed for winter recreational use and the community development aspects of the desert location.

Because of the unique environment of the Palm Springs-Palm Desert-Indian Wells area, the maintenance of turf has posed a continuous challenge for the golf course superintendent. Although the courses are in an environment where warm season grasses are best adapted, the winter use of facilities necessitates the use of cool season grasses. This requirement has been met on general turf sites, including golf fairways, by overseeding a common bermudagrass base with either annual or perennial ryegrass. However, with putting greens, the past procedure has been to use cool-season creeping bentgrass, despite its survival problems in this severe environment. Therefore, the golf course superintendent in the desert areas has had to choose between selecting a suitable creeping bentgrass or converting putting greens to hybrid bermudagrass, overseeding with cool-season grasses, and maintaining those grasses in the desert area.

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One of the factors that influences the selection is the cost of the level of maintenance required by those grasses. To assist in the decision-making process, a study was conducted to evaluate the costs of maintaining creeping bentgrass overseeded annually with perennial ryegrass and hybrid bermudagrass similarly overseeded.

The cooperation of six golf course superintendents in Coachella Valley was obtained to determine golf green maintenance costs. Three courses had Penncross creeping bentgrass and three had Tifgreen hybrid bermudagrass. Both were annually overseeded with turf-type perennial ryegrasses. Data were obtained from personal interviews with the superintendent of each course.

Individual course maintenance practices and costs were summarized. The study clearly shows not only that maintenance practices of the two types of grasses vary considerably but also that they differ markedly among courses with the same kind of grass (see tables 1 and 2). The type of material, amount and frequency of its application, equipment used, labor wages, and even type of operations vary from course to course. This reflects the differing maintenance philosophies of the respective golf course superintendents, and results in varying costs.

To determine costs, every maintenance task conducted on each green was evaluated for labor (in hours) and materials. Because the same equipment is used to maintain golf course greens regardless of the type of turf planted, ownership costs (such as depreciation and interest on investment) and operating costs (such as fuel, maintenance, and repair) are not included in this report.

In order to accurately compare course maintenance costs, adjustments were made. Cost variations due to size of greens and labor wage differences were adjusted and the cost analysis was based only on cultural management practices. For our analysis, an 18-hole course with 3.5 acres of greens and an hourly labor wage of $10.53 was used. Water cost was estimated at $20 per acre foot plus power charge of $25 per hour.

Tables 3 through 5 present the breakdown of costs by grass type and cultural management practices. Fertilizer and pesticide applications varied more among the bentgrass greens than among the hybrid bermudagrass greens, and the average application of both materials was higher on the bentgrass. Total material costs for the maintenance of the three bentgrass courses ranged from $14,125 to $36,850; those of the three hybrid bermudagrass greens ranged from $16,532 to $18,837 (table 3).

Assuming a constant labor wage, labor costs for maintaining bentgrass greens were higher than for hybrid bermudagrass greens (table 4). This is because several maintenance operations such as light top dressing, vertical mowing, and brushing are not commonly performed for hybrid bermudagrass greens as they are for bentgrass greens.

Mowing constituted a large part (about 35 percent to 75 percent) of the labor costs in the maintenance of all the golf course greens. Costs ranged from a low of $1 1,246 to a high of $24,893. As mowing is the most frequent maintenance operation for both types of grass greens, the cost variation was largely due to the type of mowing equipment used by the managers. Our survey indicated that on the average it takes 5 hours to mow 3.5 acres of greens using walking mowers versus 3 l/2 hours using the triplex (power) mowers. This means that at a wage rate of $10.53 per hour there will be an increase of about 40 percent in labor cost when using walking mowers instead of the triplex mowers. Even with fuel and oil cost adjustments for the triplex mower, walking mower costs still were higher. Furthermore, the authors are aware that even greater time differences usually exist between walking and triplex mowers. While our survey reflects a marked difference between the two types of mowers, the difference may actually be even greater.

The survey results indicate that total maintenance costs for 3.5 acres of bentgrass greens are higher than those for the same acreage of hybrid bermudagrass greens (table 5). The total cost of maintaining 3.5 acres of bentgrass greens ranged from about $55,000 to $81,900, whereas the total cost of maintaining the same acreage of hybrid bermudagrass greens ranged from $45,500 to $5 1,450.

In conclusion, the study has shown that in the Coachella Valley area, the hybrid bermudagrass green-overseeded with perennial fine-leaved ryegrass-is a less expensive putting surface to maintain than is the creeping bentgrass green. This does not mean that the bermudagrasses are the best over-all grass for every facility, because owner and player preferences and putting quality must be considered as well as budgetary constraints of material and labor.

Table 1. Frequency of Operation and Total Man-Hours for Maintenance of 3.5 Acres of Bentgrass Greens

	Annual Frequency of Operation			Total Man-Hours		
	Golf Courses			Golf Courses		
Operations	1	2	3	1	2	3
Preparation and overseeding	1	3	1	5	14	5
Fertilizing	27	43	20	345	130	228
Pesticide-fungicide application	35	63	73	432	567	1163
Mowing	305	305	311	2131*	1068**	2364***
Vertical mowing	3	3	35	35	15	319
Top dressing						
-heavy	-	1	2	-	48	129
-light	11	15	35	188	110	160
Aerating	3	4	2	274	306	195
Brushing	-	11	-	-	396	-
Irritating	-	-	-	349	350	350
Other (repair)	-	-	-	122	150	-
Total				3881	3154	5003

*Indicates a combination use of walking and triplex mowers.
**Indicates exclusive use of triplex mowers.
***Indicates exclusive use of walking mowers.

Table 2. Frequency of Operation and Total Man-Hours for Maintenance of 3.5 Acres of Bermudagrass Greens

	Annual Frequency of Operation			Total Man-Hours		
	Golf Courses			Golf Courses		
Operations	1	2	3	1	2	3
Preparation and overseeding	1	1	1	262	174	174
Fertilizing	17	21	36	318	79	142
Pesticide-fungicide application	5	42	17	187	150	142
Mowing	305	325	310	1433*	2275**	2257***
Vertical mowing	3	3	35	35	15	319
Top dressing						
-heavy	-	1	2	-	48	219
--light	11	15	35	188	110	160
Aerating	1	1	6*	112	96	37
Brushing	-	-	-	-	-	-
irrigating	-	-	-	350	350	345
Other (repair)	-	-	-	-	-	-
Total				2662	3253	3097

*Spiking operation substituted for aeritication.
**Indicates a combination use of walking and triplex mowers,
***Indicates exclusive use of walking mowers.

Table 3. Cost of Material for Maintenance of Bent and Hybridbermuda Greens

Operations	Bent Greens Golf Courses I	2	3	Hybridbermuda Greens Golf Courses 1	2	3
	(Dollars per 3.5 acres green)					
Preparation and overseeding	200	2973	400	8576	10216	9080
Fertilizing	2765	9046	17024	1562	793	1730
Pesticide-fungicide application	6350	18745	6384	1995	3216	6032
Mowing	1445*	1080*	·	1334*	·	·
Vertical mowing	·	·	·	·	·	·
Top dressing						
-heavy	·	2110	2394		105	·
-light	1697	1080	1257	·	·	·
Aerating						
Brushing						
Irrigating	1668	1816	1444	4007	2202	1995
Other (repair)						
Total	14125	36850	28903	17474	16532	18837

*Fuel and oil costs for the triplex mower

Table 4. Cost of Labor for Maintenance of Bent and Hybridbermuda Greens

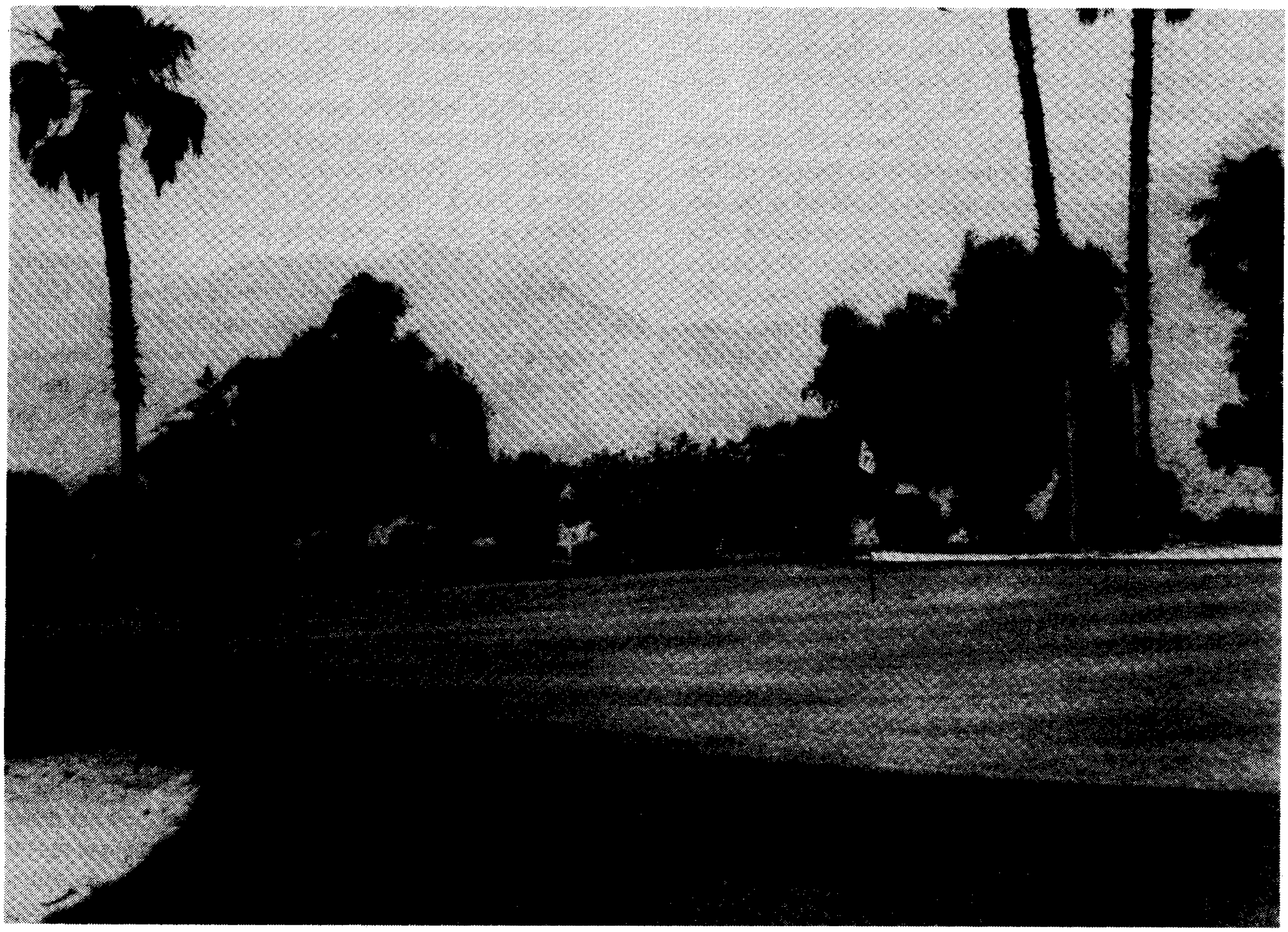
Operations	Bent Greens Golf Courses I	2	3	Hybridbermuda Greens Golf Courses I	2	3
	(Dollars per 3.5 acres green)					
Preparation and overseeding	53	147	53	2759	1832	1832
Fertilizing	3633	1369	240 l	3349	832	1495
Pesticide-fungicide application	4549	5970	12246	1969	1580	1495
Mowing	22439t	11246‡	24893§	15089†	23956§	23766§
Vertical mowing	368	158	3359	·	347	·
Top dressing						
-heavy	·	505	2306			
--light	1980	1158	1685	·	1011	·
Aerating	2885	3222	2053	1179	1011	389*
Brushing	·	4170	·			
Irrigating	3675	3685	3685	3685	3685	3633
Other (repair)	1285	1580	333			
Total	40867	33210	53014	28030	34254	32610

*Spiking operation substituted for aerification.
I-Indicates a combination use of walking and triplex mowers.
‡Indicates exclusive use of triplex mowers.
§Indicates exclusive use of walking mowers.

Table 5. Total Cost of Maintenance of Bent and Hybridbermuda Greens

Operations	Bent Greens Golf Courses I	2	3	Hybridbermuda Greens Golf Courses I	2	3
	(Dollars per 3.5 acres green)					
Preparation and overseeding	253	3120	453	11335	12048	10912
Fertilizing	6398	10415	19425	491 l	1625	3225
Pesticide-fungicide application	10899	24715	18630	3964	4796	7527
Mowing	23884t	12326‡	24892§	16423†	23956§	23766§
Vertical mowing	368	158	3359	·	347	·
Top dressing						
-heavy		2615	4700			
-light	3677	3338	2942	·	1116	·
Aerating	2885	3222	2053	1179	1011	389*
Brushing		4170	·			
Irrigating	5343	550 l	5129	7692	5887	5628
Other (repair)	1285	1580	333			
Total	54992	70060	81917	45504	50786	51447

*Spiking operation substituted for aerification.
†Indicates a combination use of walking and triplex mowers.
‡Indicates exclusive use of triplex mowers.
§Indicates exclusive use of walking mowers.



An overseeded hybrid bermudagrass green in Palm Springs.

Metal Tolerance of Bermudagrass Cultivars[1]

Lin Wu, D.R. Huff, J.M. Johnson, and William B. Davis [2]

Bermudagrass cultivars are usually vegetatively propagated clones. Distinct morphological characteristics among the cultivars are visually recognizable. Disease resistance and low temperature and salinity tolerance are known to differ between cultivars. This report presents information on metal tolerance which may be important for the dignosis of special turf problems and for cultivar selection where soils have metal toxic conditions.

Copper and zinc are essential mineral nutrients for turfgrass which can be toxic to plant growth. Six to 20 parts per million (PPM) in plant material is generally considered to be adequate. Since plants require very small quantities of these elements they are called micro-mineral nutrients. The amount of available (water soluble) copper and zinc in a normal soil at any given time is very small. If the amount of the available form is slightly increased these elements can be extremely toxic to turfgrass, resulting in growth inhibition and even the death of turfgrass. An increase in copper and zinc concentrations in the soil may be due to an increase in soil acidity, soil disturbance and washings resulting from mining operations, and other forms of industrial pollution.

Aluminum is one of the most commonly occurring elements in the soil, following oxygen and silicon in abundance. It occurs in many silicate rocks as micas and in clays, and is not toxic to plants due to its low solubility. Toxic amounts of aluminum in a soil are usually associated with low soil pH. In acid soils toxic effects on plant growth are very often due to aluminum rather than acidity per se.

The mineral chromium in soils is quite inert and usually occurs in extremely minute quantities. In soils formed from serpentines or other ferromagnesian rocks, chromium content may be high and toxic to plants. In addition, some effluent waters used for turf irrigation contain chromium at toxic levels.

Because most California soils are basic, soil acidity-induced metal toxicity is not a common problem in turf. However, metal tolerance information may be useful for certain special soil and water quality problems. The metal toxicity in soils may not reach a level lethal to turfgrass, but it may impede growth and development of the plants. Turfgrass grown in soils where toxic metal conditions may be present is more susceptible to disease and needs more frequent irrigation and fertilization due to poorly developed root systems.

Four cultivars, 'Santa Ana', 'Tifgreen', 'Tifway', and 'Tifdwarf', and a commercial seed source of common bermuda were tested for metal tolerance. The vegetatively propagated cultivars were propagated in a greenhouse potting soil, kept in a greenhouse at 30°C (86°F), with 15 hours of light, and watered with l/2 concentration of Hoagland nutrient solution. For the tolerance test, stolons with a single node and a leaf blade were collected from the greenhouse-propagated clones and transplanted in a l-liter plastic container. The culture solutions were prepared by adding $CuSO_4$ $5H_2O$, $ZnSO_4$ $7H_2O$, $Al_2(SO_4)_3$ $14H_2O$, and CrCl,.$6H_2O$ to Hoagland nutrient solution to achieve metal concentrations of: 0.25, 0.5, 1 .O, and 1.5 ppm and control for copper; 50, 100, 150, and 200 ppm and control for zinc; 100, 150, 200, and 250 ppm and control for aluminum; and 1,5, 10, and 15 ppm and control for chromium. After 3 weeks of growth, the length of the longest root of each tiller was measured. The index of tolerance was represented by the mean root length produced in the metal solution as a percentage of the mean root length produced in the control solution. For seed material 200 seeds were sown on an 8 cm x 8 cm plastic fiber filter on a nylon screen and suspended in cultural solutions identical to those for the tiller test. After 4 weeks 20 seedlings were taken from each container and the length of the longest root, the height of each seedling, and the percentage of seed germination were measured. The index of tolerance was calculated as was the rooting test of the tillers.

The results of the metal tolerance test are presented in figures 1 and 2. Figure l shows that the tolerance to each of the four metals is distinctly different among the four bermudagrass cultivars. Different metals caused different severity of toxic effects. Copper and chromium showed a severe growth inhibition at 1.5 and 15 ppm respectively. Aluminum at 250 ppm and zinc at 200 ppm severely inhibited root growth. Among the four cultivars 'Tifgreen' showed the greatest tolerance to each of the four metals. 'Tifway' showed greater aluminum and chromium tolerance but low copper and zinc tolerance. 'Tifdwarf' showed greater tolerance to copper but low tolerance to the other three metals. 'Santa Ana' on the other hand had low tolerance to all four metals. The seedling tolerance test (figure 2) showed that the four metals caused different degrees of root and shoot growth inhibition. For example, aluminum inhibited shoot growth more than root growth. On the other hand, chromium and zinc induced greater root growth inhibition than shoot growth inhibition. Copper inhibited root and shoot growth equally. Seed germination was much less inhibited by copper than were root and shoot growth.

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[1]This work was first published in The Proceedings of the Fourrh International Turfgrass Conference.

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Reports have shown that copper, zinc, and aluminum tolerances in plants are independent from each other. This study shows that chromium tolerance is independent from aluminum, copper, and zinc tolerance. It is surprising that the variation in tolerance to the four different metals was found among the four vegetatively propagated cultivars. Metal tolerance is known to be genetically controlled. This result suggests that the genetic variation of metal tolerance is extensive in bermudagrass. The metal tolerance tests may be extended to other commercial cultivars of bermudagrass to enable us to use bermudagrass as turf more effectively.

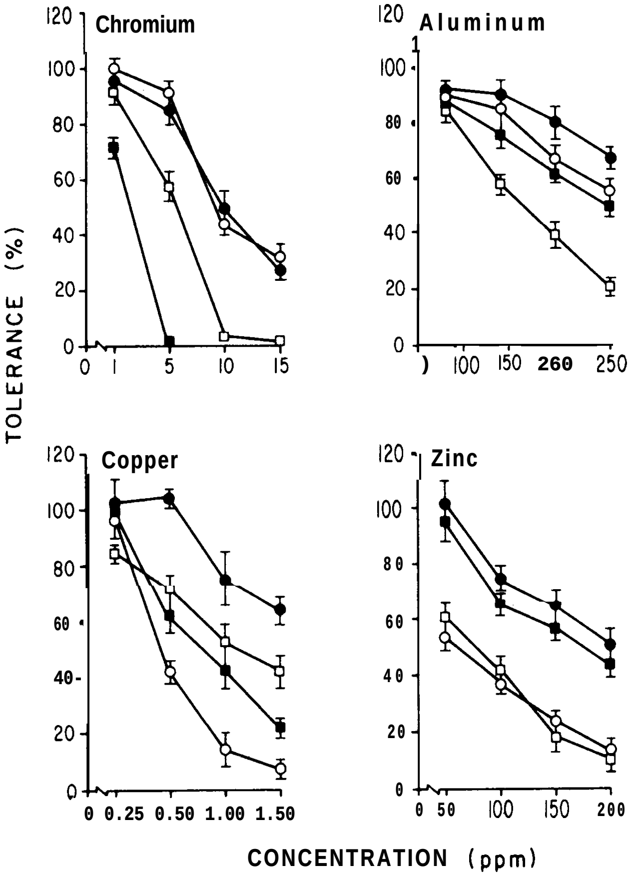

Fig. 1. Tolerance of four bermudagrass varieties to chromium, aluminum, copper, and zinc.

● 'Tifgreen'; 0 'Tifway'; ■ 'Santa Ana'; ◦ 'Tifdwarf'.

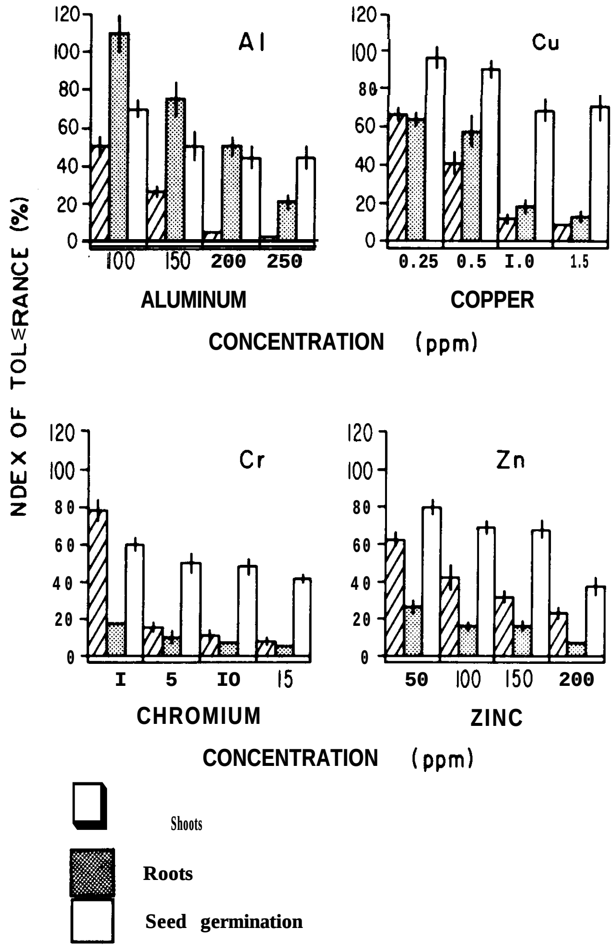

Fig. 2. Tolerance of common bermudagrass seedling root and shoot, and seed germination to aluminum, copper, chromium, and zinc.

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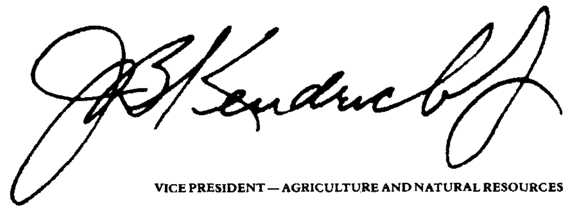

VICE PRESIDENT — AGRICULTURE AND NATURAL RESOURCES

WARNING ON THE USE OF CHEMICALS

Pesticides are pisonous. Always reed and cerefullv follow all precautions and safety recommendations given on the container label. Store all chemicals in their original labeled containers In a locked cabinet or shed, away from food or feeds, end out of the reach of children, unauthorized persons, pets, and livestock.

Recommendation are based on the best Informatlon currently available, and treatments based on them should not leave residues exceeding the tolerance established for any pertlcular chemlcnl. Confine chemicals to the area being treated. THE GROWER IS LEGALLY RESPONSIBLE for residues on his crops as well es for problems caused by drlft from hls property to other propertles or crops.

Consult your County Agrlculturel Commlssloner for correct methods of dlsposlng of leftover spray materlal and empty containers. New burn pesticide caontainers.

PHYTOTOXICITY: Certain chemicals may cause plant injury if used et the wrong stage of plant development or when temperatures are too hlgh. Injury may also result from excessive amounts or the wrong formulation or from mlxlng Incompatlble materials. Inert Ingredients, such as wetters, spreaders. emulsifiers, diluents, and solvents, can cause plant Injury. Since formulations are often changed by manufacturers, It Is possible that plant Injury may occur, even though no Injury was noted In previous seesons.

NOTE: Progress reports give experimental data that should not be considered as recommendations for use. Until the products and the uses given appear on a registered pesticide label or other legal, supplementary direction for use, it is illegal to use the chemicals as described.

CALIFORNIA TURFGRASS CULTURE EDITORIAL COMMITTEE

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

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