COOPERATIVE EXTENSION UNIVERSITY OF CALIFORNIA

California Turfgrass Culture

VOLUME 28, NO. 2 SPRING, 1978

HYDROPHOBIC SOILS ON PUTTING GREENS

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Hydrophobic soils occur throughout the world in areas such as pasture soils in Australia, brushlands in California hills, and citrus orchards in Florida (Bond, 1963; Bond and Harris, 1964; Debano et al., 1967; Jamison, 1945; Krammes and Debano, 1965). This phenomenon has also become a problem on golf greens in many parts of the United States.

In 1972, work was begun at the University of California, Davis, to study "dry spots on putting greens" (M.S. Thesis). Some generalities concerning the problem as they relate to putting greens are: (1) the nonwettable condition is more common in coarse-texture (sandy) than in fine-texture (clay) soils; (2) the surface few inches of soil are affected, not the deeper soil; (3) soil particles having this nonwettable property seem to be coated with a material or compound rendering the surface repellent to water; (4) the condition has occurred on young as well as old greens; and (5) to date no positive identification of the material has been made.

Observations on putting greens

Typically dry spots on greens are 1 to 2 feet in diameter, but if the condition is severe, larger areas may be affected. The soil under the spot is very dry and remains so even after a thorough irrigation that saturates the thatch above the dry spot. The grass soon depletes the water in the thatch, because that is the only source of moisture, and the turf rapidly returns to a severely water stressed condition.

The problem has been observed most frequently on greens constructed of amended and unamended coarse sands. The condition has also been found on sandy-loam and fine sand greens, although not as frequently.

Laboratory examination of soil cores from dry spots

Close observation was made of dry spots occurring on the experimental green at the Environmental Horticulture Department on the Davis campus, and field samples were taken from golf greens in Napa and Sonoma counties in northern California.

The soil cores were taken with a %-inch-diameter soil probe. The intact cores containing turf, thatch, and about 6 inches of soil were laid on their sides and tested for wettability as follows:

Standard-size water droplets were placed at intervals down the core profile, and the time required for the drop to penetrate the core (infiltration time) was recorded (see fig. 1). The infiltration time was used as an index of wettability: the shorter the time, the more wettable the soil.

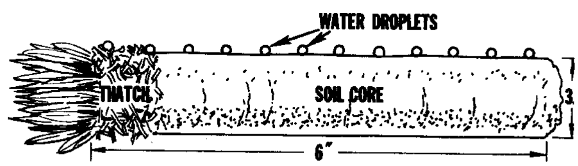

Fig. 1. Soil core on which droplets were placed to determine infiltration times at various distances from the surface.

Although the infiltration time varied from sample to sample, all those collected from dry spots showed extremely long times. Figure 2 is the wettability graph of a nonwettable core taken from the experimental green 1 hour after irrigation and tested immediately. The sand shows maximum nonwettability immediately below the thatch layer. The moist thatch absorbed the water droplet in less than 1 second; the sand below the thatch layer required 2 hours for the water to penetrate.

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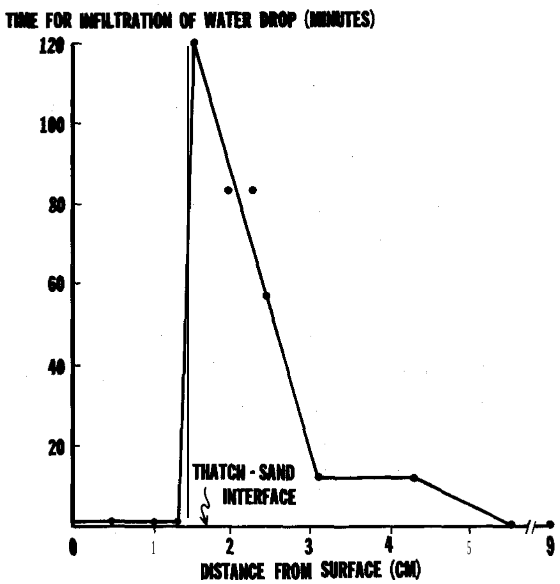

Fig. 2. Wettability of nonwettable core taken 1 hour after irrigation and tested immediately.

Most soil cores taken from greens were allowed to dry at room temperature for 48 hours before testing. In all cases, the thatch was found to be wettable, and the sand just below the thatch was the area of maximum nonwettability. Soil cores collected from normal (wettable) areas adjacent to dry spots on greens all showed rather uniform wettability profiles with maximum absorption times of 5 minutes.

The condition that induces nonwettability is drying down of the soil. Experiments using cores from wettable areas of the experimental green were dried slowly under controlled temperatures. It appeared from these tests that slow drying at moderate temperatures in the presence of roots and overlaying thatch can induce a nonwettable state in the sand, although laboratory results did not produce the extreme degree of nonwettability found on golf greens.

Recent work done at Ohio State University (Wilkinson and Miller, 1978) using a scanning electron microscope has shown nonwettable sand grains from golf greens to be coated with an amorphous organic substance interspersed with fungal mycelia. These researchers felt the hydrophobic coating may be derived from fungal growth that took place before the dry spots appeared.

Earlier work by the authors at University of California, Davis, investigated the use of solvents to remove the nonwettable substance from hydrophobic sand grains. A strong nonpolar solvent-benzene-was used to extract hydrophobic sand samples. In all cases the sand samples were still nonwettable after one extraction. Since the hydrophobic coating was not readily removed by the nonpolar solvent, a polar solvent-water-was used to extract similar nonwettable sand samples. This time the samples proved to be wettable after they were dried and tested following extraction. This result led to the theory that the hydrophobic material believed to be coating the sand grains was a polar compound.

To date no positive identification of the hydrophobic material associated with nonwettable putting green soils has been made. However, work done on sands in Florida citrus groves (Jamison, 1945; Wander, 1949) indicated that nonwettability was caused by an organic substance identified as a water-repellent metallic soap. The Florida researchers felt the regular application of fertilizers containing calcium and magnesium carbonates led to the formation of insoluble soaps through combination with fatty acids already present in the soils. Whether or not this is the case in California was not determined.

Dealing with dry spots on a green

The best corrective measure for dry spots is to prevent them from forming. The incidence of dry spots increases as turf water use increases. Dry spots are encouraged by allowing areas of a green to become too dry between irrigations. For this reason, frequent inspection of greens during the onset of hot weather is necessary to avoid undue moisture stress and possible formation of dry spots.

To alleviate a dry spot condition or restore it to a wettable state, aerating or spiking, coupled with application of wetting agents, followed by soaking usually overcomes the hydrophobic condition (Dorman, Hemstreet, and Little, 1964; Paul and Henry, 1973; Wilkinson and Miller, 1978). Soaking the dry spot with a soaker hose or low application sprinkler only wets the thatch and causes water runoff; it does not correct the situation. Hole punching breaks through the zone of maximum nonwettability just below the thatch, allowing better wetting agent and water penetration. After such treatment, the soil should be examined with a soil probe to be sure no dry soil lenses remain. Care should also be taken to prevent such areas from returning to a droughty state, because the nonwettable condition will often return.

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DROUGHT EXPERIENCE SHOWS TURFGRASS LANDSCAPE CAN BE MANAGED SUCCESSFULLY WITH LIMITED WATER

Forrest D. Cress *

Lessons learned the hard way on how to maintain landscape turfgrass in northern California during the drought of 1977 could prove invaluable to the industry at large as pressure builds to conserve water, the energy needed to pump it, and the money to pay for both.

A. C. Sarsfield of Irrigation Technical Services in Lafayette, California, reported on some of these experiences at the 1978 Turf & Landscape Institute in Anaheim.

Many managers were subjected to water limitations ranging from 40 to 60 percent of

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their previous normal use, Sarsfield noted. He said it was amazing how well most managers were able to maintain a pleasing turf suitable for its particular purposes with the use of but 50 to 60 percent of what they had come to consider normal needs.

What did northern California landscape turfgrass managers learn during the drought of 1977? "Primarily," Sarsfield said, "we learned that the basics the researchers and educators have been telling us for years-that we were applying too much water because of low cost-were really true.

"When faced with mandatory restrictions and fines for use in excess of an allotment or for gutter flooding, the simple little things suddenly become significant and are noticed. Water really does have a tendency to run downhill. Water applied too fast for too long really does puddle and run off, decreasing distribution efficiency even below that provided by your irrigation system. Shaded areas or ground cover really don't need as much water as turf in open sun."

After recognizing these basics, Sarsfield reported, many systems were rezoned to separate operation of slopes and low spots and the many areas requiring different amounts of water for efficient operation. Checks were installed to eliminate pipe drainage from low heads after each operation. Sprinkler heads were relocated to stop overthrow onto streets and other paving. Automation was added or modified so that water could be applied in several short repeat cycles to eliminate puddling and runoff.

Managers switched almost entirely to night and early morning irrigation when wind and evaporation losses were lowest. Programming was switched from the old standard repeat cycle to almost daily programming based on inspection of the landscape. Only those areas showing signs of stress were irrigated. Applications were calculated carefully to fill the soil reservoir of only the root zone with no waste below. Where water quality was poor, this lack of leaching caused problems in some areas.

Changes in maintenance procedures accompanied these irrigation improvements, Sarsfield reported. Mowing heights were raised and frequencies reduced to provide maximum soil and root shade and to encourage deeper root growth. Fertilization was decreased to light applications of nitrogen to minimize top growth. Aeration and verticutting were done in winter and spring and eliminated or minimized during the hot summer months to avoid soil moisture loss. Most shrub areas were heavily mulched to conserve moisture.

"These basic procedures, plus careful inspection and upgrading of irrigation systems for improved efficiency, uniformity, and water control, were almost universal when water limitations were imposed," Sarsfield said. "All of this enabled most turf managers who were allowed 50 to 60 percent of previous normal water use to achieve suprisingly successful turfgrass landscape maintenance."

The real problems occurred below this limitation range, according to Sarsfield. Cuts to as low as 40 percent of previous use necessitated additional and more drastic measures. Base year normal consumption figures, usually 1976, had to be analyzed carefully on a monthly or billing-period basis and the allotment percentage applied to determine the exact amount of water to be available during that period in 1977. Further complicating this procedure, that allotment often had to be used not only during the specified period but also on an individual meter basis.

The Northern California Turfgrass Council crusaded for banking and meter pooling programs but was successful only in getting banking for some of the rationing programs. Banking, Sarsfield explained, allows a carryover of water savings for any given period to be added to future allotments for use when needed. "Without it," he said, "the incentive is to use every drop of the allotment regardless of need, so that potential savings won't be lost at the end of the allotment period." Meter pooling subjects multiple meters on a single project to a single combined allotment to allow flexibility in managing total water available instead of tying use to each individual meter. "These are important points to remember should another serious water shortage occur," Sarsfield said.

Another step taken by some managers was to seek alternate sources of additional water. This generally was done by tank truck to obtain approved effluent from treatment plants or well or spring water from available, nonrestricted sources. Although expensive, Sarsfield noted, it did save many valuable plantings and strengthens the case for use of effluent to irrigate.

"Once the amount of total available water from all sources and the limitations on its use, as in the case of multiple meter installations, were determined," he explained, "the next step was to establish priorities for attempted survival.

"Golf courses placed greens and tees first, fairways from the landing area to greens next, then the balance of the fairways, and, last, the roughs. In almost every case, the last two were sure to go, and the resultant savings give indication that 'wall-to-wall' golf course irrigation could become a thing of the past."

Parks established priorities for special areas such as ball diamonds, playing fields, or special gardens, then sacrificed other areas to save them. Industrial/commercial properties concentrated on entrance areas, special gardens, and expensive ornamentals. Residential properties gave up lawns and flowers to save trees and established ornamentals.

In many cases, Sarsfield reported, permanent landscape changes were made. Small areas that were hard to maintain and irrigate without wasting water were covered with rock or were paved. Difficult turf areas, especially slopes, were converted to ground covers with low water requirements.

Drip irrigation in almost every form and fashion was tried; it proved very successful in certain applications, according to Sarsfield. He said that good emitter systems proved excellent for water conservation on widely spaced ornamentals and trees. Continuous tubing, mostly of the types with spaced emitting orifices, did well in maintaining ground covers and also in raising vegetable gardens with little water.

"The most successful installations," Sarsfield reported, "were installed with emitter orifices above the ground surface and usually covered with bark or mulch to conserve moisture as well as to hide them and prevent vandalism. Few attempts and little success have been reported in burying drip systems for maintenance of turf in northern California.

"To summarize all these experiences, a great deal of enforced learning has resulted from the severity of our drought, and even some basic thinking has been changed. This knowledge should be put to use and not forgotten. As citizens of the nation that contains 6 percent of the world population and uses a third of the world's energy, we and our industry will be under increasing pressure to save energy and conserve our limited water supply. To do that, we must all learn and practice successful landscape maintenance with limited water."

TOLERANCE OF ROOTED AND UPROOTED GROUND COVER PLANTINGS TO PREEMERGENCE HERBICIDES — Progress Report

Wesley A. Humphrey and Clyde L. Elmore"

Weed competition and control of weeds are two major factors in establishing ground-cover plantings. The earlier weed control can be accomplished after planting, the less competition there is in establishing the ground covers, and the better the appearance of the planting. Several preemergence herbicides are registered for use on some of the more commonly planted ground covers after the cuttings have been in place for various lengths of time. Additional information is needed on the effect of preemergence herbicide applications on newly planted ground covers, planted as either rooted or unrooted cuttings.

Most ornamental ground covers are planted into landscape plantings as rooted cuttings, except for some of the iceplants, particularly *Carpobrotus edule,* sometimes known as Hottentot fig. *Carpobrotus edule* has large fleshy leaves that dry out very slowly. Three- to four-node, unrooted cuttings planted into moist soil root easily.

A field study was begun to obtain some information on the tolerance of rooted and unrooted cuttings of some of the iceplants and trailing African daisy to preemergence herbicides applied the day after planting and to evaluate the resulting weed control. Plants used were *Carpobrotus edule; Delasperma alba,* white iceplant; *Hymenocyclus luteolus,* yellow trailing iceplant; and *Osteospermum fruiticosum,* trailing African daisy. Cuttings of these four ground covers were rooted in sand for 6 weeks, and on March 23, 1977, both rooted and unrooted cuttings were planted 2 feet apart in rows into a Hanford sandy loam soil. A light sprinkler irrigation was applied immediately after planting. The next day, the preemergence herbicides napropamide (Devrinol), nitrofen (Tok), oryzalin (Surflan), and prodiamine (Rydex) were applied over the planted areas in 50 gallons of water per acre. After the herbicide application, a light sprinkler application was made to wash the herbicides from the ground cover foliage and to incorporate the herbicides into the soil. The plantings were maintained with regular irrigations to provide moisture for rooting and establishment of the ground covers.

Growth evaluations and weed control ratings were made on May 3, 1977, 41 days after planting (table 1). On July 26, 1977, the ground cover plants were harvested and fresh weights recorded (table 2).

Results

Visual ratings of the tolerance to the herbicides made on May 3 showed, in general, little adverse effect on any of the ground covers planted as rooted cuttings (table 1). Unrooted cuttings of the ground covers in treated areas appeared as good as plants in the control or untreated areas, with the exception of *Delasperma* at the 8-pound-per-acre rate of napropamide. Growth of those plants was reduced considerably.

Weed control results varied; prodiamine and oryzalin gave the higher overall control ratings (table 1). Napropamide and nitrofen gave a high level of control of some weed species evaluated but did not control other species, resulting in an overall weed control of 40 to 60 percent. Napropamide provided low control of pigweed in this study but controlled both sowthistle and London rocket. Nitrofen's control of sowthistle was weak, lowering its overall effectiveness in this study.

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Fresh weights of the ground covers taken at the end of study indicate that reducing the weed competition with preemergence herbicides can result in excellent establishment of the rooted ground covers when compared with the unweeded control (table 2). Also, because no hand weeding was done in any plots, weed competition may also account for the reduced weights when comparing the various herbicide-treated plots.

Growth of treated, unrooted *Carpobrotus* was somewhat reduced when compared with that of treated, rooted cuttings, but the rate of growth was still higher than that of the untreated control. Unrooted *Delasperma* and *Hymenocyclus* both became established at a higher rate than the untreated controls in all herbicide treatments; prodiamine and oryzalin yielded the highest weights. *Osteospermum* planted as unrooted cuttings were poorly established in this study; however, a high level of growth occurred in the oryzalin- and prodiamine-treated areas when compared with the untreated control.

In this study, the four ground covers planted as rooted cuttings showed a high level of tolerance to the preemergence herbicides used. With the exception of the unrooted *Osteospermum*, the ground covers planted as unrooted cuttings did not appear, in general, to be reduced in growth by the herbicides.

This study is continuing and additional information will be reported as it is obtained.

TABLE 1. TOLERANCE AND WEED CONTROL IN ROOTED OR UNROOTED ORNAMENTAL GROUND COVERS RATED MAY 3,1977

		Tolerance*								Weed control†				
		Carpobrotus		*Delasperma*		*Hymenocyclus*		*Osteospermum*						
Herbicide	Rate/ acre	Rooted	Unrooted	Rooted	Unrooted	Rooted	Unrooted	Rooted	Unrooted	Rough pigweed	Prostrate pigweed	Sow-thistle	London rocket	All weeds
	lb													
napropamide	4	0.5	3.2	1.8	3.0	1.5	3.5	0.0	5.8	5.2	2.2	9.8	10.0	4.2
napropamide	8	0.5	3.8	1.5	5.8	1.2	4.8	1.2	5.5	6.5	4.2	9.6	9.8	5.8
oryzalin	2	0.5	3.0	0.8	2.8	1.8	3.5	0.2	4.8	9.5	6.8	9.0	10.0	8.2
oryzalin	4	0.2	2.8	1.2	4.0	0.8	4.5	0.5	5.5	10.0	9.2	9.8	10.0	9.2
nitrofen	4	0.8	0.5	0.2	1.5	0.5	1.0	0.2	4.2	9.2	6.8	3.2	9.8	5.8
prodiamine	2	0.5	4.8	1.8	1.5	1.8	2.8	1.2	4.2	10.0	9.8	9.5	6.8	8.2
prodiamine	4	0.8	2.2	1.5	2.8	1.2	3.5	0.2	4.8	10.0	10.0	9.8	10.0	9.8
control	–	2.0	3.5	2.0	3.5	2.2	4.5	1.5	6.8	0.0	0.0	0.0	0.0	0.0

* Tolerance: 0 = no effect, 10 = dead plants.

† Weed control: 0 = no control, 10 = complete control.

TABLE 2. EFFECT OF FOUR PREEMERGENCE HERBICIDES ON THE FRESH WEIGHT OF FOLIAGE OF ROOTED AND UNROOTED GROUND COVER SPECIES*

		Carpobrotus		*Delasperma*		*Hymenocyclus*		*Osteospermum*	
Herbicide	Rate/ acre	Rooted	Unrooted	Rooted	Unrooted	Rooted	Unrooted	Rooted	Unrooted
	lb	*gm*	*gm*	*gm*	*gm*	*gm*	*gm*	*gm*	*gm*
napropamide	4	37.9 c	17.7 c	6.2 cd	2.8 b	13.8 c	2.3 c	3.1 c	0.7 a
napropamide	8	40.4 c	28.0 bc	6.7 cd	3.4 b	8.7 c	7.1 c	3.4 c	0.1 a
oryzalin	2	64.4 b	43.7 ab	14.8 bc	6.6 b	32.0 b	14.1 bc	1.2 c	1.5 a
oryzalin	4	75.3 ab	56.4 a	27.2 a	9.0 ab	43.0 ab	9.2 bc	13.5 ab	0.8 a
nitrofen	4	29.4 cd	25.1 bc	7.9 cd	5.3 b	15.5 c	6.2 c	2.7 c	0.3 a
prodiamine	2	77.2 ab	51.8 a	21.2 ab	15.8 a	35.4 ab	28.0 a	7.4 bc	1.0 a
prodiamine	4	88.5 a	56.8 a	24.8 ab	16.4 a	48.8 a	21.1 ab	15.9 a	1.8 a
control	-	13.5 d	11.0c	3.6 d	1.6 b	4.1 c	0.8c	c	0.2 a

* All means followed by the same letter are not significantly different from each other at P = 0.05.

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