California Turfgrass Culture

'FORMERLY, SOUTHERN CALIFORNIA TURFGRASS CULTURE

VOL. 14 NO. 2 APRIL 1964

SOIL OXYGEN AND CLIPPING HEIGHT
Effects on the Growth of Newport Bluegrass

by
J. Letey, L.H. Stolzy, O.R. Lunt, N. Valoras
University of California, Riverside and Los Angeles

One of the very practical problems in turf management deals with the interrelated effects of clipping height, watering and soil oxygen on root growth. It is well known that close clipping causes poor root growth. In addition, it is known that poor aeration, resulting from soil compaction and overwatering can limit the growth of grass roots severely. Since the management of golf greens involves very close cutting and heavy watering, with real possibility for the development of very low oxygen supplies in the soil, we conducted experiments to determine the effects of and interactions between soil oxygen and clipping height on the growth of roots and tops and the mineral composition of Newport bluegrass as an indicator grass. The experimental results show the effects of the two factors on grass development, and also point to the kind of management practices which will allow the best root growth and turf establishment and maintenance.

Measurement and Control of Soil Oxygen

Before being able to determine the effects of soil oxygen on plant response, it is necessary to have a method to measure soil oxygen conditions. The most useful method which has been devised to date is the measurement of oxygen movement to a platinum wire inserted into the ground to represent a root. It is impossible to go into all the details involved in measuring oxygen diffusion rates, but a brief description of the principle involved can be presented. A 22-gauge platinum wire electrode, which represents a root, is placed in the soil. A silver-silver chloride half cell with salt bridge is used as the other electrode. Under specific conditions, the electric current which flows between the electrodes is dependent on the rate of oxygen movement to the platinum wire. The oxygen diffusion rate can therefore be calculated from the electric current and indicates the maximum rate of oxygen supply to the root growing in that environment.

Another problem associated with conducting an experiment on the effect of soil oxygen on plant growth is how to impose treatments consisting of various oxygen supplies. This was accomplished by designing special containers as illustrated in Figure 1. The containers were constructed of clear plastic so that root growth could be observed. A space, D, was used to circulate air around the upper part of the soil which was retained by a screen, E. After the plants had become established, latex emulsion was poured over the soil surface around the plants. The latex solidified and provided a seal, A, over the soil surface so that the only oxygen supplied to the roots was that which was flowed through the space, D. Holes F were drilled at various positions in the container so that the platinum wire electrode could be inserted to measure the oxygen diffusion rate. Water was added when necessary through a hole, C. Opaque plastic sheeting was placed around the container to keep light from the roots except when they were observed.

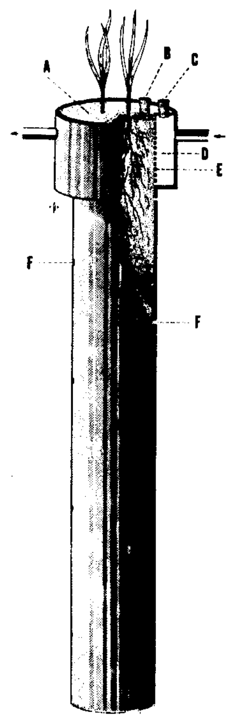

Figure 1. Special containers devised to use in measuring soil oxygen conditions.

CONTINUED

Experimental Method

Newport bluegrass was germinated in 20 containers. The grass growing in 10 of the containers was clipped to a height of one-inch and the other 10 to a height of two inches.

After the grass was quite well established, the latex seal was made at the soil surface. Air was mixed with nitrogen gas in the necessary proportions to obtain air which contained 2, 5, and 10 percent oxygen. These 3 mixtures plus regular air (21 percent oxygen) and nitrogen gas (0 percent oxygen) were flowed through the space, D, (Figure 1)of various containers to create differing oxygen levels on the plant root. Two containers of each clipping height were subjected to each of the oxygen levels.

Oxygen diffusion rates were measured three times during the experiment to determine the oxygen supply in various parts of the rooting zone. Electrodes constructed of 22 gauge wire were used.

The grass was clipped twice a week. The clippings were saved for nutrient analysis and weighing.

Root Growth

The root growth under the various oxygen treatments is presented in Figure 2 for the l-inch clipped grass and in Figure 3 for the 2-inch grass. The roots had grown to a depth of 4-inches before oxygen treatments were applied.

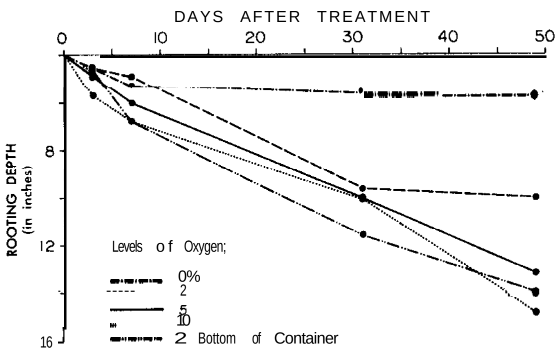

Figure 2. The effect of oxygen concentration on the rooting depth of Newport bluegrass when maintained at a clipping height of one-inch.

Let us consider the results of the l-inch clipping. The roots growing under 0 percent oxygen grew about 1 1/2 inches after treatment and then did not grow anymore. It should be made clear that although the treatment is referred to as 0 percent oxygen because pure nitrogen gas flowed through the column, not all of the oxygen was eliminated from the root zone. Therefore, the oxygen content is not completely absent even though it was very low and will be referred to as 0 percent. The roots grew to a depth of 10 inches under the 2 percent treatment and then stopped growing. In both the 0 and 2 percent treatments, oxygen supply was too low to sustain root growth. The roots under the three highest oxygen treatments continued to grow throughout the experiment.

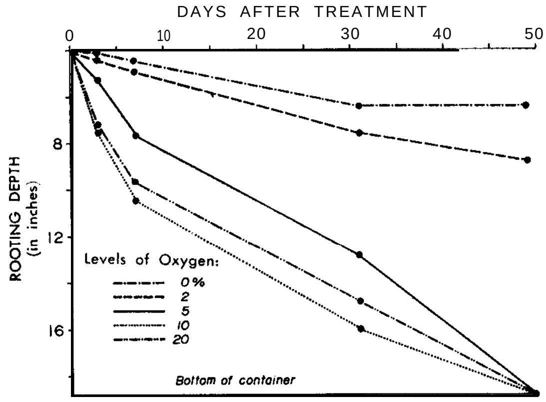

Figure 3. The effect of oxygen concentration on the rooting depth of Newport bluegrass when maintained at a clipping height of two-inches.

The root growth of grass clipped to 2 inches (Figure 3) ceased to grow under 0 percent oxygen and almost stopped under 2 percent treatment. Roots of plants growing under the 5, 10, and 21 percent oxygen treatments grew to the bottom of the containers which were 18 inches deep.

In comparing the root behavior between the two clipping practices, it is observed that the three highest oxygen treatments did not restrict growth appreciably, but the clipping height did. The roots of grass clipped to 1 inch grew more slowly than those of 2-inch clippings when oxygen was sufficient. Under the two lowest oxygen treatments, the clipping heights had little effect upon the root growth. In these cases, oxygen and not clipping height was limiting.

There was a difference between the roots of grass clipped at the two heights other than the depth of growth. The roots of grass clipped to 2 inches were larger, thicker, and appeared healthier than those of the l-inch clipped grass.

Weight of Clippings

In this experiment, top growth is evaluated as the total dry weight of the clippings and is shown in the form of a bar graph in Figure 4.

In general, the effect of soil oxygen was not great, although the amount of clippings produced was slightly less at the lower oxygen levels for the l-inch clipping height. At the 2-inch height, the oxygen concentration had a much more marked effect on growth of the grass. Under the highest oxygen treatments, more growth occurred when the grass was clipped to 2 inches rather than 1 inch. The reverse was true when soil oxygen was very low.

Nutrient Content of Clippings

The clippings were analyzed for phosphorus, potassium, nitrogen, and sodium. These nutrients were taken

CONTINUED

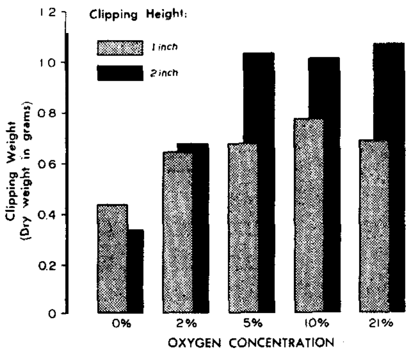

Figure 4. The effect of clipping height and oxygen concentration on tbe top growth (clipping weight) of Newport bluegrass.

up more readily by the grass under the higher oxygen treatments than under the lower oxygen treatments, except for sodium. Sodium, on the other hand, accumulated to relatively high concentrations when the oxygen was low. This information signifies that the nutrition of the plant is related to the supply of oxygen in the root zone.

Field Measurements

Information gained from a specially designed and controlled experiment as was just described allows one to make measurements in the field and interpret the results.

For example, measurements were made on three putting greens of a golf club. One of the greens was in very good condition. Another was poor with the turf dying out. The third green appeared good, but showed symptoms of getting worse and indications were that it would soon be in poor condition.

The results of the oxygen diffusion rate measurements are presented in Table 1. It is obvious from these data and the information just presented on O.D.R. and grass growth that the problem with the poor greens was insufficient oxygen.

TABLE 1. A correlation of putting green condition with oxygen diffusion rates at different soil depths.

Putting Green Condition	Depth of Measurement (inches)	Oxygen Diffusion Rate Value(l)
Good	2	51.6
	4	
	12 2	27.13.8
Bad	4	10.0
	2	10.2
Declining	4	13.6
		14.7
	12	4.1

(1) Measured in grams per square centimeter per minute (Average for 20 measurements). An oxygen diffusion rate value of 20 is considered the critical level. Values below this figure will not support satisfactory growth of grass roots.

In another case, treatments. which were put on a putting green to improve the soil oxygen were evaluated by making O.D.R. measurements*. As a regular practice, the green had g-inch holes poked about 3 inches deep by a mechanical aerator and this treatment was considered as the check. The two treatments consisted of (1) drilling 2-inch diameter holes 10 inches deep on 4-inch center spacing and backfilling with loamite, and (2) drilling l-inch diameter holes 10 inches deep on 4-inch centers which were left open for purposes of evaluation. The results are presented in Table 2. The O.D.R. was optimum to a depth of 4 inches, even on the check. The effect of the treatment was to increase the O.D.R. to a greater soil depth which should allow for a deeper root penetration.

TABLE 2. The effect of three different aeration treatments on the oxygen diffusion rate at different roil depths under putting green conditions.

Aeration Treatment	Depth of Measurement (inches)	Oxygen Diffusion Rate Value (1)
1. Regular Mechanical Procedure (check)	4	86.3
	10	43.7
		4.4
2. 2" Holes 10" Deep Backfilled with loamite	2	101.7
	4	69.2
	10	22.7
3. 1" Hole 10" Deep Left Open	4	95.0
	10	72.4
		28.3

(1) Measured in grams per square centimeter per minute (Average for 20 measurements). An oxygen diffusion rate value of 20 is considered the critical level. Values below this figure will not support satisfactory growth of grass roots.

Soil Oxygen and Irrigation Practices

Low soil oxygen is caused by both excess water and soil compaction. Water, of course, is also necessary for good plant growth; therefore, a balance between water and oxygen is needed.

It is tempting to water often during hot weather to avoid the development of dry spots. If no measurement on soil water is made, it becomes a matter of guessing when and how much water should be applied. The consequences of inadequate water are well known and become quickly evident in the turf appearance. The consequences of adding too much water are not as well recognized and may not be immediately apparent in turf appearance. Therefore, a bias toward overwatering is generally introduced where no measutement of either soil water or oxygen is taken.

If attention is turned from the top growth to the root growth, it is apparent that the extent of the root system can be greatly altered by soil oxygen. The plant is

2. THESE TREATMENTS WERE APPLIED UNDER THE DIRECTION OF WAYNE MORGAN. LOS ANGELES FARM ADVISOR.

CONTINUED

dependent upon its root system to supply both water and nutrients. The plant with a poor root system is sensitive to changes in water and nutrients because it has such a small reservoir to draw on. Management of turf with a poor root system is difficult.

The ideal situation would be to have an extensive root system develop. This would not only produce a healthy vigorous turf, but would also make management easier. It is extremely difficult to develop a good root system if measurements on soil water and soil oxygen are not made to determine when water should be added.

If a shallow root system has developed because of excessively frequent watering, caution is required in extending the period between irrigations to promote better soil aeration and, therefore, root growth. Because of the poor root system, the watering interval must be gradually extended so that all the water in the root zone is not depleted. As the roots extend to greater depths, the interval between irrigations can be extended still more until the optimum condition is reached.

Summary and Conclusions

By utilizing the platinum electrode technique and special procedures for producing variable degrees of oxygen supply in soils, it was established that root growth of Newport bluegrass was stopped when oxygen diffusion rates were 20×10^{-8} grams of oxygen per square centimeter per minute. Root growth appeared to be normal at twice this rate of diffusion. Where aeration was adequate, the root system grew faster on grass clipped at 2 inches than when clipped at 1 inch.

A correlation was found between the quality of a golf putting green and aeration conditions. Two of the greens of poor quality had oxygen diffusion rates well below the critical value established above at a depth of only 2 inches. The authors thereby conclude that aeration may be sufficiently poor in some putting greens to limit root growth.

The effectiveness of cultivation of turf in improving aeration was shown in the data and relationship of irrigation practices on aeration was briefly discussed.

Reprinted from the Golf Course Reporter, Vol. 32, No. 2, February 1964.

Sprinkler Can Tests Can Help You!

by
Wayne C. Morgan, Turfgrass Farm Advisor
University of California, Agricultural Extension Service
in Los Angeles County

How often have you, a turfgrass manager, seen a turf with a few hard, dry areas in it, while the majority of the grass is overirrigated? Unfortunately, this is a common observation to most superintendents.

We find the problem is usually caused by soil compaction or poor distribution of water from the sprinklers.

To date, mechanical aeration is the only known means to help overcome the detrimental effects of soil compaction. A new method for deep-aeration of the turfgrass soil, developed by the University of California Agricultural Extension Service, shows considerable promise for restoring weak turf on compacted soils to a healthy condition. It is hoped that a machine to do this work will be finished in the near future.

During the spring and summer of 1963, the author and the superintendents conducted can tests to check the distribution of water from sprinklers on a number of golf and bowling greens.

Cans used in these tests were lb-ounce, wax-coated paper cups with a 4 1/4-in. diameter across the top. These were placed on three-foot centers and 500 cans usually covered a golf green or over one half of a bowling green.

The contents of each can was measured in cubic centimeters (cc's) using a 11-cc graduated cylinder.The readings were recorded on a map of the test green showing sprinkler locations. The time of day, length of time the sprinklers were run, type, size and nozzles of the sprinklers, pressure, and wind conditions were noted. Most of the tests were conducted between 5 a.m. and 8 a.m. to avoid any wind interference.

Just watching the sprinklers in operation provided some helpful information. We noticed some were not turning correctly, others needed spray adjustments, and some required cleaning out.

It was found that on all seven bowling greens, the best water distribution was a four-to-one-ratio and some were as high as twelve to one. This means that four to twelve times more water was being applied to some areas than others. When possible, a two-to-one-ratio or below is hoped for.

On golf greens it was found that only three out of the twelve greens tested showed good enough coverage. All others showed ratios from four to one to as high as fifty

CONTINUED

to one.

Most of the superintendents cooperating in these tests were able to use the information received to good advantage. At two of the bowling greens more tests were run to find the best placement of the portable sprinklers.

Three bowling green superintendents found that only certain areas near the edges of the green were not receiving sufficient water. Rather than continuing to overwater the majority of the green to barely meet the needs of these areas where insufficient water was being applied, soakers, small portable sprinklers, or hand watering was used. Another superintendent changed the locations of his portable sprinklers to overcome his problems.

At one golf course where can tests were conducted on four greens, three showed good distribution of the water but one had poor coverage. Changing nozzle sizes on two of the sprinklers corrected this.

One golf green we tested showed two areas of low water application. These two areas had very weak turf and were problem spots. Changing the location of two heads provided an answer to better coverage. This superintendent is planning to reconstruct a number of new greens and stated that no grass will be planted until a can test is run first.

A golf green that showed extremely poor distribution of water had several hard, dry areas where water application was low. A map of the green showing these areas and the location of sprinklers revealed that by adding two sprinklers, the problem could be solved.

Tests were conducted on golf fairways and at a memorial park. These tests were to verify what was suspected and the results provided sufficient information for the superintendents to act to correct the problems. On fairways, parks, schools, or other turf areas, place the cans in all directions away from the sprinkler heads until overlapping occurs – spacings may then be five to ten feet.

There are several ways to interpret the results. As mentioned, one is to find the ratio of the least to the most amount of water being applied. Another is to find out how many cans have similar amounts and how greatly these differ from the majority. Some people merely add all the readings, find the average by dividing the result by the number of cans used, and see how some readings differ from this.

The uniformity coefficient (C_u) is the most commonly used statistical method for evaluating sprinkler system performance. The C_u is a percentage ranging from 0-100% 100% indicating perfect uniformity. By convention a C_u of 80% is the minimum accepted standard of performance. Any value appreciably less than 80% generally indicates poor uniformity.

The formula for determing the C_u is as follows:

$$C_u = 100 \left(1.0 - \frac{\Sigma x}{mn}\right)$$

Where: m = mean value
n = number of observations
x = deviation of individual observations from mean value m. Disregard whether positive or negative.

Example :

Calculation of Cu for 12 cans with readings as follows:
22, 26, 8, 14, 18, 30, 24, 26, 10, 12, 24, 26

$$C_u = 100 \left(1.0 - \frac{\Sigma x}{mn}\right)$$

$m = 240 \div 12 = 20$
$n = 12$
$\Sigma x = 76$

$$= 100 \times \left(1.0 - \frac{76}{20 \times 12}\right) = 69\%$$

No matter how you look at the results, you will usually find the problem areas are those where the least water is applied. Very often, the water must run much longer than needed to provide a minimum of water to the areas of low application.

To add to the problem of insufficient water at some areas, saline conditions will develop from surface evaporation if only water is applied to wet the upper inch or so of soil.

Many people do not realize how much time and money are wasted with a poor sprinkler system. If you are able to reduce your irrigation only from a 45-to 40-minute set, this is one ninth or 11%. If your water bill is $15,000 a year, this is a $1,650 yearly savings that can be used for new equipment, more sprinklers, or possibly pay increases. If you cut down more than this or if your water bill is greater, then what would your savings be? One golf course is now saving better than $5,000 a year in water costs alone since starting on a program of sprinkler testing and maintenance, more frequent aeration, and using tensiometers as a guide to irrigation.

Good turfgrass irrigation is knowing not only when to apply water and how much to apply, but is a complete program involving a regular aeration program to overcome the detrimental effects of soil compaction and to make certain that sprinklers are providing reasonably equal distribution of water.

Drainage of Recreational Areas

by
Clyde E. Houston
Extension Irrigation and Drainage Engineer
University of California
Davis

Drainage is the removal of excess irrigation water or rainfall to prevent water logging and injury to turf. Continual excess water in the turf rooting zone creates an ideal condition for soil compaction and plant disease, favors salt accumulation, and generally creates a poor condition for turf use and management.

SOURCE

The source of drainage water in arid regions is usually excess irrigation water, while that in semiarid or humid areas may be from irrigation and rainfall. The methods of applying irrigation water to soil do not permit absolute control, even with the sprinklers used for the majority of turf irrigation. Deep percolation below the grass root zone may be essential to maintain a favorable salt balance in the soil. This is especially true where irrigation water is high in salts. Even where the irrigation water is low in salts, difficulty may occur over a period of years unless sufficient water is percolated through the root zone or into a drainage facility to remove the soluble salts from the soil.

Many drainage problems with turf could be avoided by more careful planning and construction of the facility. Where land is graded and earth is moved to provide a rolling or undulating terrain, as is found in public parks and golf courses, pockets or basins always should be provided with natural outlets. Stream channels should not be obliterated without providing other channels. Athletic fields should be crowned to provide rapid surface water removal. If athletic fields are built in excavated areas sources of water at higher elevations should be checked to determine whether the water may contribute to a drainage problem on the field. Earth fill material for turf should not be applied in compacted layers similar to highway or dam construction. In all cases, holes should be augered five to ten feet into the soil to determine if there is an existing water table. In stratified soils where surplus water might become perched, observation wells should be installed, and depth to water measurements should be made periodically.

Most of us are confronted with an existing drainage problem and must find a solution to a deteriorating turf condition.

CAUSE

The first step in the solution to a drainage problem is to determine the source of the damaging water and the topographic and soil conditions that do not allow the water to drain away naturally. The topography can be determined from maps, surveys, or sometimes by eye., Soil conditions are best determined by augering holes in several locations within the problem area. As previously mentioned, these holes can be used as observation wells to determine the direction of movement and amount of ground water. The irrigation system should be analyzed to determine amount and frequency of application in relation to the amount used by the turf.

OUTLET

Once the cause and extent of a drainage problem has been determined, we are in a position to develop a solution and design a system. A drainage system is only as good as its outlet. The ideal outlet should provide free flow of water from the drain at all times and allow for the construction of drains at such depth and capacity as to give satisfactory drainage where it is needed. A continuous flow of surface water needs a clean stream channel, while an intermittently flowing stream can use a grassed waterway with a minimum of interference with recreation. Subsurface or tile water can outlet into open ditches, a covered storm drain, or a sump. Some attempts have been made, with varying degrees of success, to use dry wells. These are large diameter wells bored into an aquifer, and either left open or filled with gravel. Drainage water is allowed to run in to the well and is dispersed in the lower strata of aquifer material. These usually work fairly well at first, but silt, algae, and corrosion soon form in the well and seal the openings or pores, so that after a period of use they usually fail. In many instances, water in trunk drains or natural channels is higher than the water in a lateral ditch or tile line. This is the case in many instances of turf drainage. A successful procedure is to install a sump with a pumping plant to raise the water for discharge into the higher trunk drain. The sump usually is constructed by excavating a hole deep enough so that several 4 to 8 foot diameter concrete pipes can be placed on end to develop a tank of 10 to 15 feet overall depth. It usually extends no more than a foot above ground, and is provided with a cover. Tile lines enter the sump below

CONTINUED

the ground surface at whatever depth is necessary. On top is installed a small horsepower pump and motor with a switch which is activated by a float or electric wiring. When water in the sump rises to the bottom of the inflowing tile lines, the automatic switch starts the pump which raises the water to the surface or near the surface to discharge into the main outlet. Pumping continues until water is lowered to the lowest level without breaking suction, at which time the float or electric switch shuts off the pump. Water again rises in the sump and the cycle repeats. I feel this type of structure could be used more extensively in turf drainage.

METHODS

The two general methods for removing damaging water are by interceptor drains or relief drains. The appropriate method to use depends primarily upon the flow characteristics of the excess water, the physiographic features of the area, and the subsoil conditions. The interceptor method intercepts both surface and subsurface water and keeps it from entering an area and causing damage. For subsurface water, the drain may be either open or tile, but it is necessary to have information on subsoil conditions before making a final decision. The effect upslope from an interceptor drain is not great, but downslope may be, quite extensive.

Relief drains consist of a series of relatively close-spaced lateral lines discharging into a main line. This method rapidly removes water percolating vertically through the soil, or maintains a lowered water table to provide a well-aerated root zone for turf. This method usually is installed on relatively flat areas, such as playing fields, golf tees, and picnic areas.

TYPES

Open drains remove too much land from recreational use, except where needed to carry large amounts of run-off water. Tile lines are recommended for drainage of most turf grass areas. Concrete and clay are the commonest type used, although perforated bituminized fiber material is becoming more popular. It is seldom necessary to use larger than 4-inch tile for removing local water, and in most instances smaller sized tile is satisfactory if it is available. Other materials which appear to have promise are the many types of plastics. French drains consisting of a trench or ditch backfilled with rock, brush, organic material, or anything which conducts water more rapidly than the natural soil sometimes are used in turf areas. In my opinion, it is better to spend a little more money and install tile, once the trench has been excavated, since French drains usually plug up after a limited time of use.

FILTERS

Coarse sand or fine gravel sometimes is placed in the bottom of the trench before the tile is laid in some soils containing silt or very fine sand. After the tile is laid it is surrounded with a layer of filter material about 2 or 3 inches thick. Research and experience indicate that a filter material of about the same gradation as concrete sand is satisfactory. If the soil in which the tile is to be laid does not release small particles in water, perhaps a filter is unnecessary. Perforated tile may be laid with the holes down, but when the holes are turned up they usually are covered with a blanket of glass fiber. Complete layers of filter sand or gravel usually do more damage than good. A water bearing material must become saturated before it will release water; therefore, layered filters may mean layers of saturated soil rather than that just around the tile line.

DEPTHS AND SPACING

The depth of tile installation is dependent upon a number of factors, such as source of water to be removed, type and structure of soil, rooting depth of turf, equipment for installation, and desires of management.

When it is desirable to remove rain water or irrigation water as it percolates through the soil profile, tile lines may be relatively shallow, say 3 or 4 feet. When the need is to lower a wafer table and maintain it at 5 or 6 feet, then 6 to 8 feet depth is desirable. Many turf grasses will root to 3 feet; therefore, it is reasonable to expect a nonsaturated condition in the root zone. Where pan conditions exist in the soil profile, it may be advisable to place tile either on or above the pan, which may give a more shallow depth than usually desirable. Spacing of tile also depends upon the previously mentioned factors, plus the depth. Under similar conditions of water, soil, and turf, a deep tile system may have a greater distance between laterals than a shallow system.

Although excellent progress has been made in recent years in developing drainage criteria and investigational tools, it still takes good judgment, local experience, and trial and error – along with a thorough understanding of basic principles – to design a successful drainage system.

Mechanical Gopher Control on Golf Courses

by
Seward T. Besemer
Farm Advisor, San Diego County

Gopher control on golf courses has been achieved with a mechanical bait applicator. This machine, developed by the University of California, has already proven highly effective in the rapid reduction of large gopher populations in field crops and orchards.

At the Singing Hills Country Club, a 36-hole golf course in San Diego County, gophers were reduced 90 to 95 per cent in the border areas. This golf course, as are many in California, is surrounded by natural wildlands which produce a continuous supply of gophers. The cost of hand trapping involved about one man-day per week plus cost of traps. Unsightliness of mounds, the hazard to golfers, the inconvenience in mowing fairways and damage to mowers are other costs impossible to appraise.

Before the mechanical bait applicator was used at Singing Hills, gophers were a major maintenance problem. Now, the golf course superintendent states the problem is minor.

On March 4, 1963, the gopher bait applicator was used to treat about 2 miles of the outside "rough" areas of the golf course. Within 30 days, the hand trapping which previously averaged about 60 gophers per week, was reduced to about 12. These 12 per week were obtained mostly from interior areas of the course far from the gopher bait application. It was estimated that gophers were reduced 90 to 95 per cent in the border areas. On July 4, four months after control was initiated, control was still 80 to 90 per cent at the perimeter of the golf course.

The mechanical bait applicator is a 3-point hitch, tractor mounted device not requiring the operator skill for successful gopher control by hand methods. The machine creates an artificial burrow which gophers intercept. Three per cent strychnine grain is metered into the burrow at a cost of about $4.00 per mile for material. The poison is not exposed to pets or children.

Damage to the turf is negligible unless the shank which makes the burrow is thrown sideways by a stone or tree root. Since the shank runs 8 to 10 inches deep, water lines should rarely be a problem. In the application at Singing Hills, the slit in the turf was neatly closed by following the machine with one large front tire of a golf cart. Good soil moisture is needed for easy operation of the bait applicator, to make a well-formed burrow, and to minimize injury to the turf. For non-irrigated rough areas it would be necessary to treat after a good rain. The edge of irrigated fairways could be treated any time.

Two treatments per year of a golf course perimeter should maintain good gopher control. Experience with the mechanical gopher bait applicator on golf course turf suggests that it could be used to control gophers on football fields, cemeteries, parks, and other large turf or landscaped areas.

The author appreciates the advice of Maynard Cummings, Extension Wildlife Management Specialist, University of California; also, the cooperation of Ralph Lemke, Golf Course Superintendent, Singing Hills Country Club, Debesa, California.

CALIFORNIA TURFGRASS CULTURE is sponsored by the Federated Turfgrass Council of California and is financed by the regional councils and other turfgross organizations of the state. Communications should be sent to the editor, Dr. Victor B. Youngner, Departmenr of Floriculture and Ornamental Horticulture, 300 Veteran Avenue, University of California, Los Angeles 24, California. The Federated Council consists of the officers of the three regional councils. Subscription to this publication is through membership in one of the regional councils listed below:

SOUTHERN CALIFORNIA TURFGRASS COUNCIL

President .... Cal Trowbridge
P.O. Box 102,
Mira Loma, California
Vice President .... William Hull
Secretary .... Frank Rich
Treasurer .... H. Hamilton Williams

NORTHERN CALIFORNIA TURFGRASS COUNCIL

President .... Paul Paulsen
Vice President .... D. W. Galbraith
Secretory-Treasurer .... Allen J. Brown
634 – 14th Street
Oakland Park Dept.
Oakland, California

CENTRAL CALIFORNIA TURFGRASS COUNCIL

President .... James D. Watson
Vice President .... John Engen
Secretary .... Lewis LeVal ley
Fresno State College
Fresno, California
Treasurer .... Don Nishinako