

## Drainage Principles

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The purpose of this discussion is not so much to describe methods of installing the "right" drainage system, as to analyze the principles in water movement and retention which would affect the performance of a given drainage system and, consequently, management practices. The discussion will be directed primarily to turf or landscape situations. Drainage will be defined as the removal of excess water from the rooting zone.

Why is drainage necessary? Plants require oxygen to carry out their life processes in a manner very similar to animals. We are aware of the consequences of removing the oxygen supply from animals. Plants, likewise, suffer from an insufficient oxygen supply. Plants differ from animals, however, in their means of obtaining oxygen. Animals breathe air into the lungs where part of the oxygen is replaced by carbon dioxide and expelled back into the atmosphere. Animals will get by quite well as long as the air contains a required percentage of oxygen and the passage from the atmosphere to the lungs is not closed off. Plant roots, on the other hand, are dependent upon diffusion of oxygen. Diffusion is a process whereby movement is from an area of high concentration to an area of lower concentration. Since oxygen is used by the plant root, the concentration there will be reduced and, therefore, oxygen will diffuse toward the root. Oxygen can diffuse through air quite rapidly, but diffuses through water very slowly. The difference in speed is about 10,000 times. The soil water content will, therefore, greatly affect the oxygen supply for the root. In fact, we consider that we have excess water only when it is sufficiently high to limit the oxygen supply.

How can we determine whether the soil water content is high enough to restrict oxygen supply? Certainly when essentially all of the pores are filled with water, oxygen supply will be insufficient. Whether oxygen is inadequate when a certain amount of the pores are filled with air depends upon the soil and can really only be determined by measuring the oxygen diffusion rate through the soil. This measurement requires special equipment and will not be discussed further.

In our definition of drainage, we indicated removal of

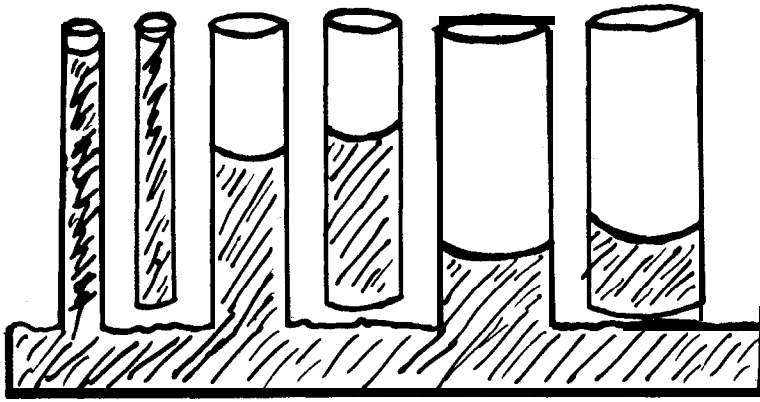
excess water from the rooting zone. It becomes apparent, therefore, that what might be adequate for a plant species with one type of root system will be inadequate for plants which have different rooting habits. Installed drainage systems should be tailored to the plant which is to be grown in the soil.

Since drainage is required for the removal of excess water, seemingly drainage would not be necessary if excess water was not added to the soil either by rainfall or irrigation. In southern California, rainfall is not great so irrigation becomes the controlling factor and, if properly managed, could eliminate the requirement for drainage. This is partly true. The performance of a drainage system becomes less critical if good irrigation practices are followed. Complete elimination of drainage is not possible, however, because of one other factor. Whenever water is added to the soil, a certain amount of salt is added along with the water. As the water evaporates from the soil or is transpired by plants, the salt is left behind. As time goes on, the salt concentration in the soil builds up to a level which can damage plants. It is necessary to occasionally add excess water to wash the salts from the root zone. The salts will not, of course, be washed out if the water can't be drained. (In this connection, it should be remembered that with subsurface irrigation systems, water is released underground. As water is used at the soil surface, water will move up to replace it. In so doing, salt will accumulate. Water must be applied at the surface periodically to wash the salts from the soil.)

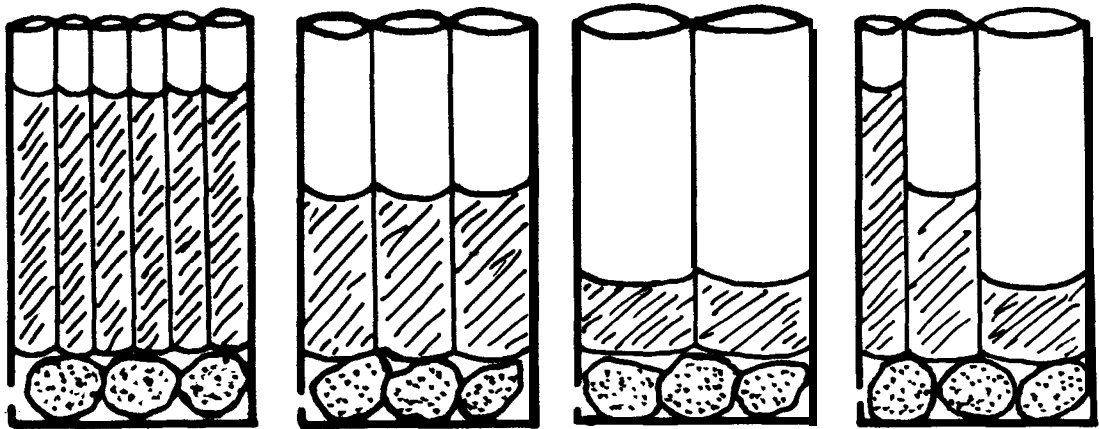
Some soils have permeable subsoils so that water can percolate through. If these soils are not burdened by overirrigation, no artificial drainage system needs to be installed. However, if the soil has layers with very low permeability or water is applied indiscriminately, a drainage system must be installed.

Let us assume that we have a subsoil which has very low permeability for water. This situation is not greatly unlike having water in a soil-filled container. If sufficient water is added, the soil pores become filled with water because there is no outlet. When a hole is drilled in

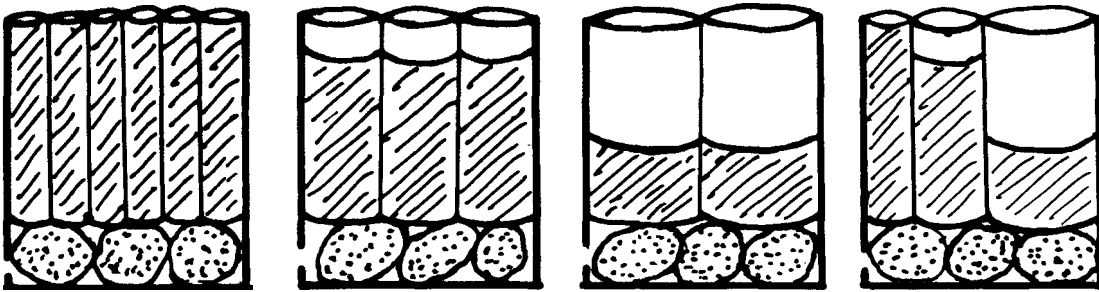
**A**



**B**



**C**



**D**

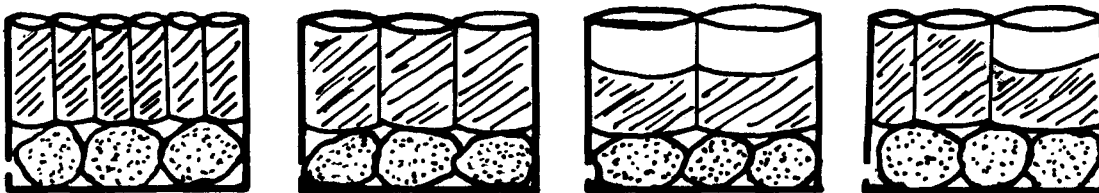


Figure 1

the bottom of the container, some of the water may drain from the container. However, not all of the water is removed but some is retained by the soil. The amount which is drained and is retained depends upon the type of soil in the container and, also, on the size of the container. To take extreme cases - if the container were filled with gravel, almost all of the water would be drained which would allow for good aeration but leave very little water for plant use. On the other hand, if the container had clay, almost no water would drain from the container even if a hole were placed in the bottom. From these examples, it becomes apparent that the drainage performance will be dependent upon the type of soil or soil mix. An effective drainage system for one soil type may not be so good for another type.

#### Water Retention

An important factor to consider in drainage is water retention. Let us examine this aspect more thoroughly. One way to visualize water retention is on a capillary tube (tube with small diameter opening) basis. If the ends of small tubes were placed in water, water would be drawn up into the tubes. This is illustrated as part A of figure 1. (The drawings in figure 1 are schematic and are not to scale). The height that water would be drawn into the tube would depend upon the size of the tube. The smaller the opening, the higher the water would be drawn. These tubes could then be held vertically out of the water with the end open at the bottom, and water would still be retained.

The results of placing these tubes in containers of various sizes, filling them with water, and allowing them to drain is illustrated in parts B, C and D of figure 1. (Again the drawings are not to scale. Actually the gravel at the bottom of the container under the tubes would be much larger in proportion to the tubes than could be indicated in the drawings). In examining the drawings, some factors should become apparent: (1) no matter what combination of tubes is placed in the container, the bottom of all tubes will contain water; (2) as the height of the container is increased, a larger fraction of the tubes will be drained at the surface and, therefore less water will be held at the surface; and (3) the smaller the tubes which are contained, the greater the quantity of water retained.

How does this apply to a soil? The soil pores are not, of course, straight round tubes. Soil consists of pores of various sizes and shapes. Nevertheless, the smaller pores can retain water to a greater height than larger pores, just as the capillary tubes did. In general, the larger the soil particles the larger the pores. Therefore, the general behavior of various soil materials is similar to what would be predicted from the capillary tube analysis.

Let us now see how these principles can be applied to a drainage system. The drainage system recommended

by the USGA can be used as an example to discuss. A complete description can be found in the September 1960 issue of USGA Journal under the title of "Specifications for a Method of Putting Green Construction." Their diagram is reproduced as figure 2. What can be concluded from this system based upon the three factors determined above? Before water will drain into the gravel, the sand and soil above the gravel must be saturated with water. The height to which saturation will occur is dependent upon the type of soil material in position E. If the soil is fine and has very fine pores, it is possible to have the soil saturated to the surface. In this case, poor soil aeration would result, even though a drainage system is provided. That is why it is important to use a soil mixture which has the physical properties which are recommended for the system. Let us assume now that a soil mix is available for position E (in the figure) which is coarse enough to partially drain at the surface and be saturated for only a few inches at the bottom. What would happen if this soil mix were put in 24-inches thick, instead of 12. This would have the effect of increasing the length of the "capillary tubes" and cause more pores to be drained at the surface (in a soil mix there is a variety of pore sizes and not just one). By increasing the thickness from 12 to 24-inches, the moisture retained at the surface would be reduced. The amount of water remaining for plant use would also be reduced. The soil mix to be used for 24-inch thickness should be somewhat finer than for 12.

That the amount of water which drains increases as the thickness of the top layer increases can easily be demonstrated with nothing more than a rectangular sponge and a pan of water. Wet the sponge thoroughly, and carefully lift it from the water in a flat position. Use care not to squeeze the water from the sponge. Allow the water to drip until it stops then turn it edge-wise, so that the longest side is vertical. More water should drain from the sponge.

The following general conclusions can be drawn:

(1) The type of soil material to be used is dependent upon the depth to the gravel layer. In general, the greater the depth to the gravel layer, the smaller the soil pores. A soil material can be analyzed by a laboratory which is equipped to measure soil physical properties to determine its suitability for use in a given drainage design. (Unfortunately, there are presently very few commercial laboratories which qualify for this analysis.)

(2) The zone for root growth will be limited to the soil depth provided; and, if water is frequently added to cause drainage discharge, the lower part of the top layer will be saturated and will not allow root growth. As previously indicated, the plant species to be grown should be considered, because some plants can do fairly well with a shallow root system, while others cannot.

(3) Management practices will depend upon the type

of drainage system installed. If a shallow system is installed with an accompanying coarse soil-mix used for the surface, little water will be retained for plant use.

Frequent irrigation will be necessary to provide adequate water for plants. On the other hand, if deeper systems are installed, watering will have to be less frequent, but of slightly longer duration. Irrigation is the key to the problem. It is very difficult, if not impossible, to have optimum irrigation practices without an indication of the moisture in the rooting zone. Tensiometers are proving to be useful for this purpose. They should become more useful as more is learned about their use in turf, and systems are designed for the job. If good irrigation practices are followed, the functioning of the drainage system becomes less critical because its only function will be for the periodic leaching of salts. It is not necessary that water flow from the tiles everytime that water is applied, unless excess is applied. Excess water should be applied only when the salt content is approaching a level which will be damaging to plants. Application of excess water every irrigation is not only expensive because of the water cost, but fertilizers are leached from the soil as well as salt. The application of excess water every irrigation will also place a greater demand upon having a well-designed and properly functioning drainage system.

## CROSS SECTION OF A PUTTING GREEN PROFILE SHOWING A TRENCH AND TILE LINE

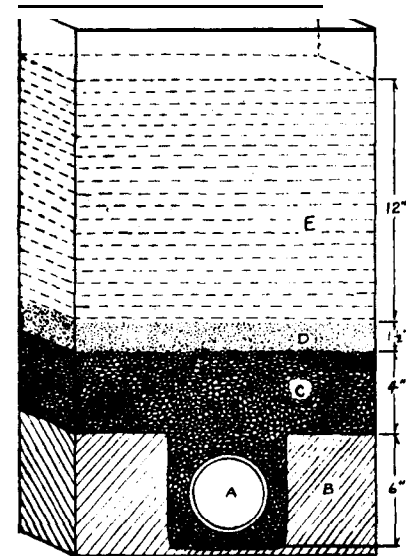


Figure 2

- A. 4-inch diameter tile.
- B. Subgrade of native soil or fill material.
- C. Gravel -preferably pea gravel of approximately 1/4" diameter. Minimum thickness 4 inches.
- D. Coarse Sand - this sand should be of a size of 1 mm. or greater. 1½ to 2 inches in thickness.
- E. Topsoil mixture. Minimum thickness of 12 inches.

## Concept of Sprinkler System Selection

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Purchasers of sprinkler irrigation systems, in the final analysis, are really interested in only two things - performance and cost. I believe the customer should start in selecting a system by determining first just what he wants this system to do. The customer should be concerned with the following points:

1. Area to be covered
2. Hours available for watering
3. Amount of water to be applied
4. Type of system
5. Maximum wind under which system must operate
6. Maximum precipitation rate permissible
7. Uniformity of precipitation
8. Service life of the various components of the system

I would like to discuss each one of these points, as the customer's first job is to set up specifications for each to assure himself of getting the kind of system he wants.

### 1. AREA TO BE COVERED

The area to be covered is determined by the customer and should be specified by means of an accurate plot plan. Areas that cannot be watered, as well as watered areas, must be clearly shown as this will play an important part in selecting the type of heads best suited to the job.

### 2. HOURS AVAILABLE FOR WATERING

In large area jobs the cost of the system is affected to considerable extent by the time allowable to apply a specified amount of water. As an example, watering 100 acres at the rate of 1 1/2" per week will require 4,085,000 gallons per week. This, divided by seven days per week, equals 572,640 gallons per day. If the watering must be accomplished in a six hour period the flow required will be 95,440 gallons per hour, of 1,590 gallons per minute. This means that the mains and pump will have to be big enough to deliver this volume of water. If,

on the other hand, 12 instead of six hours can be allotted to this watering job, then the flow required would be cut in half to 795 gallons per minute. This could make as much as \$14,000 to \$18,000 difference in material costs alone for this system.

Watering time available is limited by use of the area. On a golf course, for example, it is generally not permissible to water during playing hours. However, in some cases for extreme drought conditions, an exception might be made to this in order to reduce the cost of the system. Watering time available may also be affected or further restricted by wind conditions if serious wind conditions frequently prevail for a large percentage of the day or night. Watering will have to be done during the periods when the wind is low.

### 3. THE AMOUNT OF WATER TO BE APPLIED

A sprinkling system is purchased to water the grass and particularly to water it when it needs it the most, that is, during the driest season of the year. It is weather conditions that determine how much water has to be applied, that is, temperature, air movement, and humidity, are the factors that determine the amount of water that is extracted from the soil and consequently how much has to be applied to maintain satisfactory growing conditions. This figure varies from a low of 1/2" per week to a high of 2" per week.

### 4. TYPE OF SYSTEM

The various types of systems available may be broadly classified as:

- A. Hose and portable sprinklers
- B. Quick couplers with impact sprinklers
- C. Pop-up rotor sprinklers with automatic controls

The hose and portable sprinkler is the lowest in first cost but highest in operating cost. The quick coupler system is intermediate in first cost and operating cost. The full automatic system with pop-up rotors has the highest first cost, but the lowest operating cost. The operating cost is enough lower so that the higher first cost is quickly recovered.

Only the customer can decide which type of system best meets his needs. But unless he is for some reason only concerned with the first cost, he will almost invariably find the automatic system is the best choice.

### 5. MAXIMUM WIND CONDITIONS UNDER WHICH THE SYSTEM MUST OPERATE

Very few people not intimately associated with turf sprinklers realize how drastically large sprinkler systems are affected by the wind and how little wind it takes to affect the performance of the system. The effect of wind on the performance of various rotor pop-up heads varies slightly, but only slightly. So we can use the following as a guide as to head spacing required for various wind conditions.

<u>WIND</u>	<u>MAXIMUM TRIANGULAR SPACING</u>
0 to 3 miles per hr.	60% of the diameter
3 to 5 miles per hr.	50% of the diameter
5 to 7 miles per hr.	40% of the diameter
8 to 10 miles per hr.	30% of the diameter

This does not sound too serious until you realize the number of heads required goes up in inverse proportion to the square of spacing. Therefore, four times as many heads would be required to operate successfully in an eight to ten mile per hour wind as are required in a zero to three mile per hour wind. Most customers would prefer to schedule watering times to coincide with periods of the day or night when the wind is low rather than paying the much greater cost involved in installing a system which will achieve good coverage in the wind. This is something the customer should thoroughly understand and be able to specify what he wants before he starts to buy a system.

### 6. MAXIMUM PRECIPITATION RATE PERMISSIBLE

Precipitation rate is the average rate expressed in inches per hour at which the sprinklers deliver water. A low rate is anything under .30 inches per hour. Medium rate would be .45 inches per hour, and anything over .5 inches per hour would be considered a high rate. Good soil conditions on flat ground can successfully use a high rate. However, any of the following conditions may indicate the need for a lower rate: heavy soil, soil compaction, sloping areas, or any other condition which results in a low infiltration rate.

Sometimes it is hard to tell in advance how high a precipitation rate can be used successfully on all parts of the turf area, so it is preferable to specify the lower rates of precipitation which will give the least trouble with run-off in problem areas. Fortunately, this is one desirable feature that generally does not increase the cost of the system. So usually there is no reason for specifying anything other than a low rate of precipitation.

### 7. UNIFORMITY OF PRECIPITATION

This is the measure of the efficiency of the system, and it is remarkable how much difference there can be between a good and a poor system. The industry needs better methods of measuring and specifying uniformity of precipitation as it is such an important measure of the efficiency of a system. One method that was developed by the agricultural sprinkler industry expresses the uniformity of precipitation as a CU factor, which is a percentage figure arrived at as a weighted average of a number of readings. Another way of expressing uniformity is as a ratio of the precipitation in dry areas versus wet areas. Personally, I prefer the ratio method as the agricultural method works on averages and it is possible to have a fairly high or good CU factor and still have many small problem areas.

## 8. SERVICE LIFE OF THE VARIOUS COMPONENTS OF THE SYSTEM.

There is a terrific difference in the life expectancy in the various components used in sprinkling systems, even under ideal conditions. And adverse conditions can cause further shortening of the life expectancy. For example, water hammer or associated high pressure can cause premature failure of pipe and fittings. Abrasive or corrosive water can shorten the life of rotor heads, especially where the mechanism is exposed to the water stream. The sum of these variables on rotor heads, as an example, can result in an operating life as low as 50 hours to as high as 5,000 hours. So you can see how important it is for the customer to specify durability.

It should be possible to obtain a five year durability on heads, controls and valves, and a 15 year on pipe and fittings.

The customer should know and specify what he wants the system to do, then leave to responsible experts the job of designing the system which will meet his specifications.

I think that if a customer will concentrate on acquiring the knowledge he needs to properly specify what he wants the system to do, he can then shop for a system, taking full advantage of free competitive enterprise to obtain competitive prices, and still be assured of getting a system which will meet his needs.

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# Melting-Out of Bluegrass

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University of California Agricultural Extension Service

Melting-out of Kentucky bluegrass, *Poa pratensis*, is caused by the fungus *Helminthosporium vagans*. The disease is favored by cool (50 - 60 F.), moist conditions such as prevail in the San Francisco Bay region during the winter months. It has been found to be serious in this area from December through February although symptoms occur at other times of the year. Melting-out appears first in shaded and poorly drained areas of turf and is most severe on closely clipped grass.

Typical symptoms include a general thinning out of the turf and browning of lower leaves. Circular to elongate, purplish or brown spots with straw-colored centers (easily visible with a hand lens) occur on leaf blades, leaf sheaths, and stems. Crowns and roots are frequently attacked. Very often a yellow-tipped leaf blade indicates a lesion on the leaf sheath.

The causal fungus probably survives in infected bluegrass plants and debris as fungus threads (mycelium) and as spores. The spores can be windborne but the fungus may also be seedborne.

### Observations on Resistance

Some bluegrass varieties are resistant to melting-out. In the winter of 1963-64, the disease was severe in an experimental planting at the University of California Gill Tract in Albany. Four varieties of bluegrass were present in the planting: common, C-1, Merion, and Park. These were visually rated on May 15 for disease severity. By this time all varieties had partially recovered from the disease as growing conditions improved with the advent of warmer weather.

Table I presents average ratings for each of the varieties based on 20 replications. The figures indicate the relatively high degree of resistance to melting-out

exhibited by the Merion variety. More than half of the Merion replicates showed only a few leaf spots. Melting-out was not apparent in this variety even in areas of shade and poor drainage. Park variety, on the other hand, exhibited severe melting-out in several replicates and at least moderate symptoms in the remainder. Common Kentucky bluegrass was rated as only slightly less affected than Park. C-1, although apparently more resistant than common and Park, also showed some Melting-out in all replicates.

TABLE I  
Disease Severity<sup>1</sup> of Four Varieties of Bluegrass  
Infected with *Helminthosporium vagans*

Variety	Disease Rating <sup>2</sup>
Merion	1.5
C-1	3.5
Common	4.0
Park	4.5

1. Average of 20 replications per variety.
2. 1 = A few leaf spots but no melting-out  
5 = Moderately severe melting-out  
10 = Turf completely killed

### Fungicides Evaluated

In 1964, several fungicides were applied on November 16 and 25, and December 7 and 28. Disease ratings were made on January 11.

Table II indicates the degree of fungicidal phytotoxicity and disease severity in plots treated with various fungicides as compared to that in non-treated plots. All ratings represent the average of four replications. Common, C-1 and Park varieties were observed to exhibit

severe melting-out in the non-treated replicates. Merion, again, showed resistance to melting-out and was not included in the comparisons.

All of the fungicides tested gave good control of the disease symptoms. PMA caused severe yellowing of the turf after one application, especially on Merion. Cycloheximide caused a relatively slight yellowing. The same was true of dyrene but only after four treatments. Folpet appeared to be an excellent fungicide for control of melting-out under these conditions. PCNB also gave excellent control and was subsequently observed to provide control over an extended period of time. It should be noted that this material has not been generally recommended for the control of this particular disease.

**TABLE II**  
**Disease Control and Phytotoxicity Ratings**  
**of Five Fungicides<sup>1</sup> Applied to Common, C-I,**  
**Merion and Park Varieties of Bluegrass**

Treatment <sup>2</sup>	Rate/l,000 sq. ft.	Disease Severity <sup>3</sup>	Phytotoxicity
No treatment		4	
dyrene (50%)	1/2 oz.	1	Some yellowing after four treatments.
cycloheximide (5%)	12 grams	0	Slight yellowing.
PMA (10%) <sup>4</sup>	1 fl. oz.	0	Severe yellowing, especially Merion.
folpet (75%)	3.2 oz.	1	0
PCNB (75%) <sup>5</sup>	4 oz.	0	Slightly less growth, color normal.

1. Description of Fungicides:

- PMA = phenylmercury acetate
- dyrene = 2,4-dichloro-6-(O-chloranilino)-triazine
- folpet = N-(trichloromethylthio) phthalimide
- PCNB = pentachloronitrobenzene

For trade names of these chemicals see Turfgrass Disease Control, U. C. Agricultural Extension Service publication AXT-166.

2. Applied November 16, November 25, December 7 and December 28, unless otherwise indicated.

3. 0 = no disease evident

- 1 = a few leaf spots but no melting-out
- 2 = slight melting-out
- 3 = moderate melting-out
- 4 = severe melting-out

4. Applied only once on November 16.

5. Applied also on November 5.

**Timing of Fungicides Important**

Timing is an important consideration in the chemical control of melting-out. The first application should be made before the disease symptoms become severe. We suggest that the first fungicidal treatment be made in the fall when the growth of the grass has slowed. It may not be necessary to apply the fungicides as frequently as was done in this trial.

**Cultural Control**

The fact should not be overlooked that the causal fungus cannot produce the disease without accompanying conditions that are either unfavorable to the turf or favorable to the fungus and to the development of the disease. Such conditions are described in the opening paragraph. Some of them can be eliminated or minimized by proper cultural techniques.

Close clipping should be avoided. It severely weakens the grass and greatly increases susceptibility to the disease. It is recommended that Kentucky bluegrass be mowed no lower than 1 3/4 inches, especially when accompanying conditions tend to favor disease.

Where feasible, shade should be reduced. Good drainage lessens the chances of recurring severe attacks by Helminthosporium. Care should be taken to provide good drainage, both on the surface and internally, when constructing a new turf area. After the turf is established, good aeration should be encouraged by minimizing the development of compaction and thatch build-up. Periodic aerification should be employed to correct these conditions as they develop. Irrigating the full root depth when needed (with consequent longer intervals between waterings) will produce more vigorous turf. This in turn will tend to reduce compaction due to traffic on wet turf.

Maintaining a program of adequate nitrogen fertilization will favor the health of the turf and its ability to outgrow attacks by the fungus.

**CALIFORNIA WEED CONFERENCE, 1966**

The 18th Annual California Weed Conference will be held January 18, 19 and 20, 1966 at the Sainte Claire Hotel, San Jose, California.

Some of the subjects to be discussed are trends in mechanization, weed control by aircraft, regulatory problems, industrial weed control and weed control in ornamentals and groundcovers.

# Alternaria leaf Spot and Petiole Blight of Dichondra

R. M. Endo

A fungal disease, normally causing only slight damage as leaf spots on Dichondra tepens, has been observed in several southern California counties causing a severe dieback and thinning-out of dichondra lawns and seed fields.

According to Mrs. Lilly Davis, formerly with the Department of Plant Pathology, UCLA, the disease is first evident as light brown, dead flecks on the leaves. Later, the leaf spots have a pale center, which is usually surrounded by a series of concentric rings of brown tissues. The edge of the leaf spot is generally dark brown in color. Individual spots range in size from 1 to 5 mm. but larger spots may form by the merging of individual leaf spots.

The most damaging phase of the disease occurs when the fungus, apparently Altetnatia porrie f. sp. solani, infects the leaf petioles, causing brown lesions. In addition, leaf spots at the base of leaves may enlarge and extend into the petioles. When petiole lesions are large, they may kill the petiole and with it the attached leaf. When the disease is severe, the turf takes on a thinned out, burned, withered appearance due to a killing of petioles and leaves to the ground line.

Roots and runners are apparently not infected, but

Mrs. Davis found seed infection to be of common occurrence. It is not known whether the fungus penetrates only the seed coats or the seed embryo as well. The source of primary inoculum is probably infected seed. When planted, infected seeds produce plants with typical damping-off symptoms, in the form of dark brown lesions on the hypocotyl and cotyledons.

The disease is common in southern California in late spring and fall since disease development is favored by cool temperatures. During hot weather, the disease generally declines.

The protectant fungicide Zineb, sold under the trade names Patzate or Dithane Z-78 (65% wettable powder) has controlled the disease satisfactorily in tests conducted by Mrs. Davis. Apply at the rate of 1 tablespoon per gallon of water mixed with the addition of a wetting agent such as Dteft, Tide, Vel, etc. Because the fungus produces abundant asexual spores (simple, seed-like reproductive bodies that germinate in water and initiate new infections) that are wind-borne, and may be present on the lower as well as the upper leaf surfaces, thorough coverage of plants and plant debris with the fungicide is necessary to obtain good control. It may be necessary to reapply the fungicides several times at 7 to 14 day intervals to bring the disease under control.

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