

# California Turfgrass Culture

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## Integrated Pest Management for Turf

*Victor A. Gibeault, W. Robert Bowen,  
Howard D. Ohr, Ivan J. Thomason and Forrest Cress\**

One of the "buzz words" today in commercial agriculture and urban horticulture is integrated pest management (IPM), a concept that amounts to more than just the same old method of pest control wrapped up in a new package.

IPM is defined as multiple tactics used in a compatible manner in order to maintain pest population below levels that cause economic or unacceptable aesthetic "injury without posing a hazard to humans, domestic animals, or other nontarget life forms. Integrated means that a broad interdisciplinary approach is taken, using scientific principles of plant protection, to fuse into a single system a variety of management strategies and tactics. This integration of techniques must be compatible with sound turf management practices, and it must be economically feasible. Pests include all biotic agents (that is, insects, nematodes, weeds, fungi, viruses, and vertebrates) that adversely affect turf species. Tactics include regulatory, genetic, cultural, biological, physical, and chemical procedures.

### **Regulatory**

Regulatory procedures normally involve governmental or industry practices such as exclusion of pests by quarantines, seed inspection, certification of planting stock and limitations on the use of certain highly susceptible species.

### **Genetics**

Genetic control tactics are essentially our oldest and most widely used approach to pest control. Genetic tactics involve either the identification and use of turf species with naturally occurring resistance to pests and/or diseases, or the introduction of specific genes for resistance into an otherwise desirable plant species.

In addition to genetic selection for resistance, the identification and use of highly vigorous and competitive plant species can foster successful competition with weed species leading to the latter's elimination. Similarly, the reduction or elimination of disease activity by selecting resistant species and varieties has long been practiced. These concepts have been repeatedly demonstrated in numerous species/variety evaluation studies.

### **Cultural**

Cultural control tactics are among the oldest and most widespread techniques. They include sanitation (removal of material harboring a pest, thereby disrupting the pest's life cycle), watering, fertilizing, aerifying, and mowing practices which enhance the growth of turf so that it can resist pests. Planting time also can play a vital role in cultural control. Incorrect maintenance results in a weakened turf sward of poor density and vigor that encourages pest activity and invasion.

Because of their similar genetic makeup, individual plants in a given single-variety turfgrass planting should react similarly in their susceptibility or resistance to disease. In such a monoculture, one might think that the introduction of a pathogen capable of causing a disease on that variety would proceed immediately to destroy the entire planting. This, however, is not usually the case.

In order for a disease to develop, the host must not only be susceptible and the pathogen be present, but the environment also must favor it. Specifically, this includes the microclimate, soil factors, and cultural practices. These environmental components usually don't act independently but are part of an interrelated complex that operates to the advantage of the pathogen or to the disadvantage of the host during disease development.

\*Environmental Horticulturist, Extension Entomologist, Extension Pathologist, Program Director, Pest Management, and Extension Communications Specialist, respectively, University of California, Riverside.

Characteristically, a given planting of grass does not contract every disease it is susceptible to, nor is it attacked by a different disease every year. Usually, a history of disease develops in which a single disease or a few diseases occur in a particular planting from year to year. A thorough knowledge of what diseases occur on that grass, the time of year they normally appear, the weather conditions that precede their development, how cultural practices affect their development, and what chemical control methods can be used to prevent their appearance or inhibit their progress can be a big help to the turf manager in keeping turfgrass healthy.

Likewise, weed establishment, growth and development are greatly affected by cultural practices. As an example, long-term low mowing of Kentucky bluegrass at the University of California South Coast Field Station resulted in the predominance of oxalis, annual bluegrass, and spotted spurge. At the same location, mowing several perennial ryegrass varieties at a 3/4-inch cutting height resulted in two times as much area being covered by spotted spurge as the same varieties cut at 1 1/2 inches. In addition to stimulating weed invasion, low mowing also has been shown to influence the establishment of a particular type of weed species. The annual bluegrass that spreads under a putting green height is frequently the creeping, perennial *Poa annua*, subspecies *reptans*. Upright annual *P. annua*, subspecies *annua*, predominates in higher cut turf.

Fertilization practices also have a large impact on weed invasion in turf. In the previously mentioned perennial ryegrass variety study, it was observed that the amount of spotted spurge invasion was related to the annual nitrogen fertilization treatments. For some varieties, the area covered by spotted spurge decreased as the amount of nitrogen increased. The same trend has been noted with other broadleaf weeds. A fertilization program that results in a nutrient imbalance (i.e., low phosphorus, potassium or other essential nutrients) also can hasten weed invasion. Weeds fare better in poorly fertilized turf than in well-fertilized swards because of the greater density, vigor, and overall competitiveness of well-fertilized turf.

Healthy, weed-free turf requires irrigation practices that adequately meet its evapotranspiration requirements. Too little water, too much water, too frequent irrigation or too infrequent irrigation will enhance suitable conditions for the growth and development of unwanted weed species. The scenario for this degenerative process is: Poor irrigation practice → decreased turfgrass roots, vigor, density- weed germination and survival of adapted species -weed colonization → need for herbicides, renovation or reestablishment.

Compaction and excessive thatch accumulation must be controlled in order to retain a weed-free turf. A compacted soil or heavily thatched profile will restrict water,

air, and nutrient entry, thereby reducing the root growth and, ultimately, the vigor of turfgrasses. The presence of the summer annual, knotweed, is one of the best indications of compaction because of its tolerance and competitive advantage in compacted soils. Commonly, a heavily thatched turf will have high populations of shallow-rooted, moisture-loving species such as crabgrass, annual bluegrass, and others. The correct timing and frequency of aerification and vertical mowing practices are a small price to pay to keep a healthy grass stand.

## **Biological**

Biological control, broadly defined as the regulation of pest organisms by their natural enemies, is a desirable and economical method of pest control. Biological control organisms can be parasites, predators, or diseases.

Except for the use of a sporeforming bacterium to control Japanese grubs, successful biological control programs have not yet been developed for turfgrass insect pests. Although there are naturally occurring parasites and predators of turfgrass insect pests, their success in suppressing damaging pest population hasn't been determined. Insect pest hosts must be present in turfgrass at population levels sufficient to sustain their parasites and predators, and the tolerance level permitted doesn't lend itself to the use of known biological control agents. For example, the tolerance level for insect pests in golf course greens is zero.

The frequent use of herbicides, fungicides, bactericides, nematicides, and insecticides also inhibits biological control as a viable insect pest control method for turfgrass.

*Bacillus popilliae*, which afflicts Japanese beetle grubs with what is commonly known as milky disease, has been used with fair to good results. The Japanese beetle appears to be the main host for *B. popilliae*, although other scarabaeid larvae also are known to be susceptible to it. This bacterium is sold commercially and applied as a dust which contains its spores. Experience has shown that following application of the spore-containing dust, several years are required for milky disease to appreciably reduce beetle populations.

One method of biological weed control that has not received sufficient research attention pertains to recognizing, understanding, and using allelopathy (natural biotic toxicity against other species) in turf establishment and maintenance.

Although the biological balance of microorganisms in the turf environment undoubtedly plays a major role in disease development, there are few examples of biological control of turf diseases.

## **Physical**

Physical control tactics consist of procedures such as

heat treatment of soil before planting, mechanical devices such as traps for insects and vertebrate pests, or noise devices to discourage injurious birds. Ensuring good surface and internal water drainage is another example of a physical control tactic.

### **Chemical**

Chemical control tactics have been discussed and are familiar to all readers. They involve the use of pesticides applied as sprays, drenches, or granules, and, in some cases, the preplant injection of soil fumigants.

The selective use of chemicals still must remain the turf manager's hard line of defense against turfgrass insect pests. Although good turfgrass management can significantly reduce insect pest activity, it does not eliminate the need for chemicals when serious problems develop. In effect, good management reduces the number of insecticide treatments needed to control a pest outbreak when it does occur.

When a disease occurs, the identity of its pathogen is determined, cultural practices are investigated to determine if they are creating or intensifying the problem, and the history of the turf is reviewed to determine if it has occurred in the past.

Once it is determined that cultural practices cannot be modified to help suppress a disease outbreak, the use of fungicides becomes necessary. Any fungicide applied should be specific for the fungus involved and used in accordance with state regulations and label rates. A fungicide should not be relied upon as the sole control measure for a disease but should be regarded as one essential component of an integrated pest management program.

Similarly, specific herbicides are registered for most turf weeds and can be used on the common turfgrass species without injury. Care must be taken to correctly identify the weeds and desired grass species. The most effective herbicide for a specific weed problem should

be applied according to label recommendations when it can provide maximum control. The cause of the weed problem should be ascertained, and maintenance practices should be changed to minimize the weed's recurrence.

Highly sophisticated IPM programs involving plant growth modeling and integration of all pest, disease, and weed control tactics into a cohesive system have not been developed for turf managers. However, many factors of this pest control approach are well understood and can lead to setting priorities for the life cycle of turf.

Selecting the best adapted species and varieties based on the climatic and edaphic zones and the ultimate on-site use and management is very important. Other major considerations include provisions for an adequate irrigation system, sufficient soil-fertility level, and proper pH. The ideal time to assess and plan for the solution of weed, disease, nematode, and insect problems is before planting turf. The next stage in the life cycle, planting, and seedling establishment, is a critical time in a pest management system.

Vigorous seed or vegetative material that is free of weeds and seeded at the correct rate gives rise to uniform dense stands that can do much to properly establish turf. Following this juvenile period, one of the most effective and valuable IPM practices is frequently observing (scouting) the turf, which requires rigorously disciplined inspection for pests, disease, and weed problems. Close observation, assessment, and recordkeeping can help ensure that the proper pest control action will be taken at the most opportune time. It also can lead to adjustments in management practices that will alleviate or moderate pest problems.

Finally, if pesticides must be applied – and they are indispensable tools in many situations – then apply the one that is most effective, least toxic to nontarget species, and least persistent in the environment.

## **Influence of pH on Pesticide Activity**

***M. Ali Harivandi\****

The effect of soil environment on chemical pesticides applied to the soil has been studied extensively. As a major element of the soil environment, pH has attracted considerable attention in this work but has proved disappointing as a predictor of pesticide activity and/or its behavior in the soil. The great variation in molecular

structures and chemical properties of pesticides, plus the complexity of a soil medium, create major difficulties in any evaluation of pH effect on pesticide behavior.

Despite the complexity of the subject, however, there is general scientific agreement that soil pH (or pH of any medium, for that matter) does influence pesticide

\*Farm Advisor, Alameda, Contra Costa, and Santa Clara counties.

activity. It may directly or indirectly influence the detoxification of pesticides by affecting the ionic or molecular character of the chemical itself, the ionic character of soil colloids, the soil's cation exchange capacity, or even by affecting the inherent capacity of the microbial population to respond to a given chemical.

### **What is pH?**

pH is a numerical designation of acidity and alkalinity in soils and other chemical systems. Technically, pH is the negative logarithm of the hydrogen ion activity of a solution. Values of pH range from 1 to 14, with pH 7.0 indicating neutrality. Higher values indicate increasing alkalinity (basicity), and lower values indicate increasing acidity. Since pH is a logarithmic value, each pH unit is ten times more acidic than the next highest unit and ten times more alkaline than the next smallest unit. For example, a solution with pH 5 is ten times more basic than a solution with pH 4, while it is ten times more acidic than a solution with pH 6.

The pH of the soil solution is important to plant growth for many reasons: 1) it affects nutrient availability; 2) it influences the toxic effects of some nutrients; 3) it influences soil microbial activity; and 4) it affects the functioning of root cells (which in turn regulate the process of water and nutrient absorption in plants). The pH effect of plants via its effect on synthetic organic pesticides has also become an important issue and has triggered considerable study. What follows is a presentation of some of the experimental results which bear directly on pesticide management.

### **pH effect on spray mix preparation**

There are times when a pesticide unexplainably fails to control a pest. In an experiment (Miller, 1980) with the insecticide trichlorofon, the following half-life was demonstrated when the insecticide was added to spray solutions of varying pH:

| pH | half-life        |
|----|------------------|
| 8  | 63 min (1.05 hr) |
| 7  | 6.4 hr           |
| 6  | 88.8 hr          |

In other work (Miller, 1980), the half-life of trichlorofon in water, at 30° C and protected from light, was:

| pH | half-life |
|----|-----------|
| 9  | 2.4 hr    |
| 7  | 14.4 hr   |
| 5  | 112.8 hr  |

Evidence, therefore, suggests that as pH of the spray solution increases, both activity and duration of trichlorofon decrease. A generalization from this about all pesticides would be risky, because pesticides vary so much in chemical structure. However, this type of reaction may explain the ineffectiveness of some pesticide applications.

### **pH effect on pesticide compatibility**

When two or more pesticides are combined and the effectiveness of one or all components is reduced, the chemicals are said to be "incompatible." Many pesticide labels and compatibility charts state that certain pesticides, e.g., organophosphates and carbamates, should not be combined with alkaline materials such as lime, or even with water in the alkaline range. This is extremely important, since ignoring this direction can cause the pesticide's active ingredient to break down in the tank, thereby becoming totally ineffective. Even if breakdown does not occur, persistence of the pesticide's residues may be altered. (Whether the residual life is prolonged or reduced will vary between pesticides.) The precipitation of copper carbonate when copper sulfate is mixed with hard (alkaline) water is a good example of the role pH plays in pesticide compatibility.

Likewise, most organic fungicides (acidic in reaction) should not be combined with compounds whose pH is higher than 7.0. The fungitoxicity of carbamate fungicides and the pesticidal value of compounds, such as Aramite, Lindane, Parathion, and Malathion, are significantly reduced by alkaline reactions.

Chemical incompatibility, then, is frequently the cause of poor performance of multiple pesticide combinations, and pH is the major cause of this incompatibility.

### **pH effect on pesticide behavior in soil**

Only since World War II has the magnitude of pesticide use warranted much experimentation. And relatively few experiments have been done on the behavior of pesticides in soil systems. The work which has been done indicates that the fate of pesticides in the soil depends on at least seven factors: 1) chemical decomposition; 2) photochemical decomposition; 3) microbial decomposition; 4) volatilization; 5) movement; 6) plant uptake; and 7) adsorption.

Each of these activities is related to all the others in a complex pattern of interactions, but the adsorption-desorption phenomenon is the dominant factor in the behavior of a pesticide in soil. Adsorption refers to the binding in thin layers of molecules or ions on surfaces of

<sup>2</sup>Use of the term "soil pH" as though it had only one component is inaccurate. In reality, there are two parts to soil pH: the pH of the bulk solution ("external pH" or "bulk acidity"), and the pH at the clay surface ("internal pH" or "surface acidity"). For the practical purposes of this paper, however, it seemed most helpful to speak of their combined effects as the "soil pH."

a solid. Desorption refers to the opposite phenomenon: the release of molecules or ions from a solid's surface. The adsorptive force can be strong enough to immobilize the adsorbed ion or particle. Adsorption of pesticides in soils therefore reduces their effectiveness.

Adsorption and desorption of a pesticide in soils is influenced by the: a) physico-chemical nature of adsorbate (i.e., pesticide); b) physico-chemical nature of the adsorbant (i.e., clay); c) electrical potential of clay surfaces; d) temperature; and e) soil PH. Generally, adsorption of organic chemicals to soil colloids increases as soil pH decreases.

Adsorption of a pesticide to soil colloids reduces its phytotoxicity. This is nicely shown in work by Adams, Pritchard (1977) (Fig. 1). This figure shows the effect of soil pH on the phytotoxicity to soybeans of three s-triazazine herbicides. The soybeans were grown in a silt loam soil for 28 days. According to this report, little reduction of plant growth occurred at pH 5.8 over the

range of Secbumeton concentrations used. As pH increased, the  $GR_{50}^3$  decreased. In other words, at higher pH more herbicide is available for absorption by plants due to less adsorption of the chemical by soil colloids. This relationship holds for both prometryne and secbumeton. Atrazine adsorption seems not to be influenced by pH. The authors of this study suggest that in calcareous soils (high pH) s-triazazine herbicides should be used cautiously to avoid phytotoxicity.

Another experiment (Liu, Cibes-Viade, and Koo, 1970) studied the effect of pH on adsorption of ametryne and diuron by clay loam soil (Fig. 2). As the diagram indicates, an inverse relationship between adsorption of both herbicides by clay loam soil and pH occurred. However, pH had more influence on the adsorption of ametryne than of diuron.

It must be noted that considerable work by other scientists indicates that the pH dependence of adsorption does not apply to all pesticides. For those pesticides whose adsorption is pH dependent, many are less strongly adsorbed, and thus more active, in calcareous or alkaline than in acid soils.

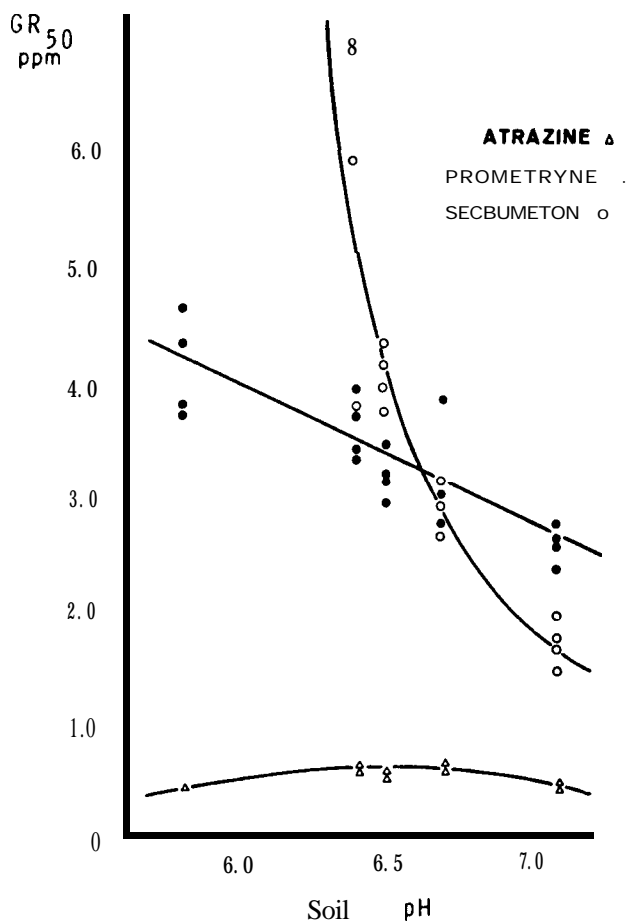


Fig. 1 Effect of soil pH on the soybean phytotoxicity of three herbicides growing in silt loam soil. (From: Adams and Pritchard, 1977.)

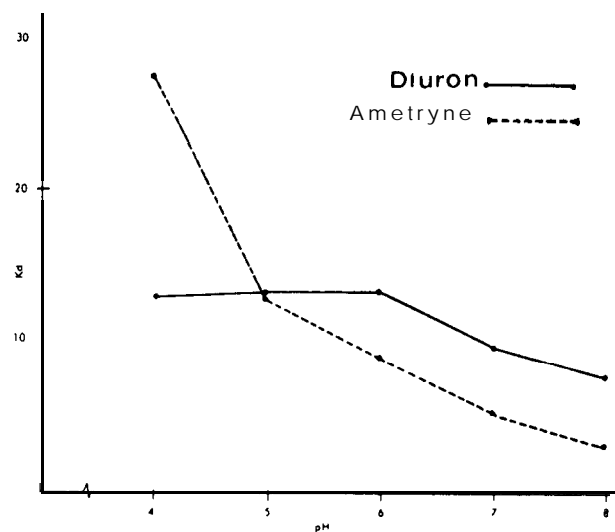


Fig. 2. Effect of pH on adsorption ( $K_d$ ) of  $^{14}C$ -ametryne and  $^{14}C$ -diuron by clay loam. (From Lui, Cibes-Viade, and Koo, 1970.)

### Conclusions

Since soil and water pH can be controlled at least to a certain extent in agricultural practices, attention to the effect of pH on adsorption, penetration and persistence of pesticides is warranted. Further studies are clearly called for in such a large and complex subject and in an area where it is difficult to generalize results from one

<sup>3</sup>GR<sub>50</sub> is defined as the concentration of herbicide required to induce a 50% reduction in the dry matter production of a plant after a specified period of growth.

pesticide to another. Existing evidence does permit limited confidence in the following recommendations:

- Do not use acidic or alkaline water to make spray solutions of pesticides (i.e., use water with a pH as close to 7.0 as possible).
- Check the pH of water at least once a year if either deep well or municipal water is used. Check pH more frequently if shallow wells or pond or lake water are used.
- If the pH of spray water is above 7.0, ferrous sulfate, vinegar or commercial buffering agents may be used to lower the pH.
- Make spray solutions immediately before use.
- Don't store leftover spray solutions for future use.
- Always use compatibility charts when combining pesticides. When in doubt, do not use combinations.
- Check the soil pH regularly (at least once a year). Try to maintain a soil pH close to neutral (7.0).
- Lime or sulfur applications for improving soil pH should not be made at the same time soil pesticides

are being sprayed (unless otherwise okayed by nest-tide label).

- Be cautious if using pesticides in calcareous (alkali) soils. Many pesticides are much more soluble and active at these pHs, resulting in greater movement in the soil and greater plant uptake. This may be especially important when phytotoxicity to adjacent plants is a problem (e.g., trees in turf).

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## Factors in Turfgrass Irrigation

M. Ali Harivandi\*

Irrigation is one of the most important turfgrass management practices. Water is needed by turfgrass in all its growth stages, from the smallest seedling through maturity. However, in arid, semi-arid, and also in metropolitan areas of the United States, the wasteful use of water in turfgrass irrigation has become of great concern. In places such as California, characterized by long, hot-dry summers and shrinking water supplies caused by increased population, turf managers must learn to use water more efficiently. This is possible only if all factors involved in turfgrass irrigation are considered and well understood.

### **Why irrigate**

Almost every physiological reaction of all living organisms, animals and plants, requires water. Without water, metabolic activities cease, and an organism dies. Water is also essential for proper plant nutrition. Food elements must be dissolved in the soil solution in order to be taken up by plant roots. The role of irrigation in this plant-nutrient relationship is to provide the "solution" which, moves to root surfaces and is eventually absorbed and translocated throughout the plant. In this manner a constant supply of food for healthy plant growth is maintained.

\*Farm Advisor, Alameda, Contra Costa, and Santa Clara counties.

Water absorption by a root system is regulated in part by the amount of water available in the soil. Water availability is determined both by the average soil moisture stress and by the soil's hydraulic conductivity. Both of these are more favorable for plant growth when the soil is moist.

Plants absorb water primarily through their root systems, use a minute amount, and discard most of it through transpiration. If for any reason and to any degree transpiration exceeds water absorption by the roots, growth is retarded. Transpiration in turf is controlled almost entirely by factors such as temperature, humidity, light and wind. So, the need for water over any period of time depends on these factors as well.

A turfgrass manager must consider climatic factors and many other factors when planning irrigation. The following areas are of major concern in adapting turfgrass irrigation to soil and climatic conditions:

### 1. Amount of water applied

A single answer cannot be given with respect to how much water to apply. The proper amount depends on both root depth of the particular grass grown and the soil's water-holding capacity within that root depth.

Turfgrass species differ in their rooting ability. Some have deep root systems, others shallow. Approximate rooting depths of turfgrasses commonly grown in California are given in the table. As the table shows, warm season grasses generally produce deep root systems, while almost all cool season grasses have shallow root systems. (Tall fescues, with an intermediate root system, are an exception.)

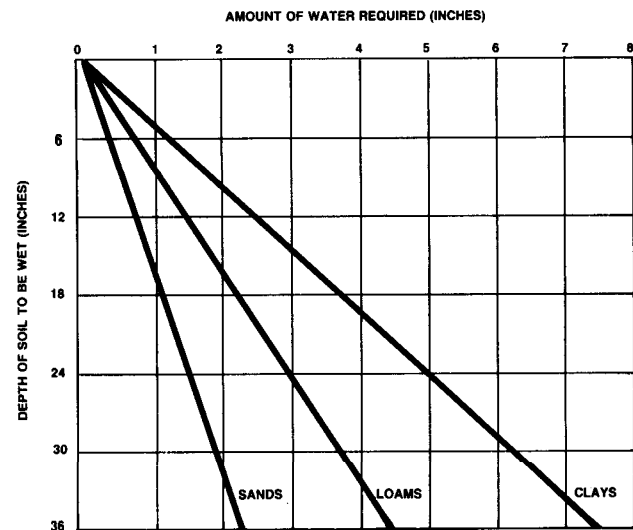
Also, commonly grown turfgrasses can be classified according to the following degrees of drought tolerance: High drought tolerance: bermudagrass, zoysiagrass, tall fescue, and red fescue.

Intermediate drought tolerance: Kentucky bluegrass, perennial ryegrass, and St. Augustinegrass.

Low drought tolerance: colonial bentgrass and creeping bentgrass.

| Approximate Root Depths (Under Normal Use Conditions) of Commonly Grown Turfgrasses |               |
|---|---------------|
| Grass species   | Root depth    |
| <b>Shallow:</b>   |               |
|   | <i>Inches</i> |
| Creeping bentgrass  | 4- 18         |
| Colonial bentgrass  | 4- 18         |
| Perennial ryegrass  | 6- 12         |
| Creeping red fescue   | 6- 18         |
| Kentucky bluegrass  | 6- 18         |
| <b>Intermediate:</b>  |               |
| Tall fescue   | 18 - 48       |
| <b>Deep:</b>  |               |
| Bermudagrass  | 18 - 96       |
| Zoysiagrass   | 18 - 96       |
| St. Augustinegrass  | 18 - 96       |

Rooting depth and tolerance to drought must be considered when watering any species of grasses. The deeper the root system, the more water applied at each irrigation and the less frequent the irrigations. The water-holding capacity of soils depends on their texture. The heavier (more clay) the soil is, the higher its water-holding capacity and, in turn, the more water necessary to wet it to a given depth (compared to a sandy soil). As the figure indicates, almost 1 1/2 inches of water are required to wet a loam soil to a depth of 12 inches. The same amount of water wets a clay soil to a depth of 7 inches and a sandy soil to a depth of 24 inches.



Inches of water required to wet soils to given depths (assuming no runoff).

After the soil has been wetted once to a desirable depth, the amount of water applied in subsequent irrigations depends upon the plants' interim water use. The proper application will refill the storage volume. Under certain conditions, a little extra water may be applied for salt control. Excessive irrigation not only wastes water through runoff but also results in leaching of nutrients and water-logged soil.

Because determining how much water is required to refill the storage volume is not easy, it is very seldom done. Instead, a reasonably sufficient amount of water is added. Too much irrigating is almost always the practice; the task is to decide on a reasonable application. One approach is to consider how much water can be used each day and then to base estimates or irrigation needs on this use.

If we assume that the maximum evapotranspiration (ET) from a turfed area is approximately 1/4 inch per day (4 acre-feet/growing season), we can estimate the irrigation requirement based upon this amount. (This figure is for illustrative purposes only. Actual figures

vary between locations according to temperature, humidity, light and wind. A precise figure may be obtained from local weather data and should be adjusted according to weather conditions, including precipitation.) If, for example the frequency of irrigation is four days, and assuming the average ET is 1/4 inch/day, approximately 1 inch of water should be applied at each irrigation. In cooler seasons or during cloudy weather, less water is lost through ET each day, and the amount of water applied is adjusted accordingly. If the rate at which water is delivered from a sprinkler system is known, we can calculate how long it will take to apply a given amount of water. The gallon-per-minute ratings of sprinkler heads are provided by the manufacture for various pressures. The time required for the desired application is then calculated by the formula:

$$\text{Minutes} = \frac{(\text{inches desired}) (0.6) (\text{square feet of coverage})}{\text{gallons per minute delivered}}$$

If, as a reasonable example, the sprinkler was rated at 3 gpm and covered a circular area 20 feet in diameter, the time required to deliver a 1-inch irrigation would be:

$$\frac{\text{minutes} = (0.5) (0.6) (314)}{3} = 31.5$$

If the equipment rating or the deliver pressure is not known, cans may be placed within the sprinkler area and the actual rate of application measured.

## 2. Rate of application

The rate at which we apply irrigation water to grass depends on the general turf management program. Ideally, application rate should not be faster than the rate at which water will enter the soil. If we apply water faster than this, runoff results. Besides being wasteful, runoff causes pooling in low spots which, in turn, causes problems such as disease infestation.

Each irrigation system should be designed initially with an application rate suitable for the soil texture and slope on which it is used. Obviously, a sandy soil can absorb water much faster than a clay soil, so the rate of application can be higher in sandy soil. Similarly, the greater the slope, the lower the rate of water application in order to minimize runoff. Fortunately, modern irrigation systems make it easy to set a controller which will provide several irrigation cycles of short duration rather than a single cycle of longer duration. This can be essential where either soil or slope makes it inadvisable to apply all the water needed in an irrigation at once.

Besides soil texture and slope, two other factors are important in the rate of water application: thatch and the degree of soil compaction.

Thatch may become nonwettable due to chemicals produced during decomposition. Once such material has dried, it sheds water and is not easily rewetted. A turf manager should examine the turf for thatch buildup, removing thatch when necessary.

Heavy traffic on turf should be avoided as much as possible, especially traffic by equipment or vehicles when the soil is wet. Of course, this cannot always be avoided. Aerification techniques such as coring can be of considerable help to increase water infiltration in compacted soils and should be practiced regularly.

## 3. Frequency of application

Let the condition of the grass and soil, not the number of days since watering, be the guide to irrigation. Watering daily or every other day just because the water is available can be detrimental to the turf and wasteful.

Applying water before it is needed is contrary to good conservation practices and should be avoided as much as possible. Applying water a bit too late may temporarily affect the vegetation's appearance, but it is seldom permanently harmful if the correct amount is applied in subsequent irrigations and if water distribution is uniform. Applying water a little bit late also permits the use of plant appearance as a guide for the time to irrigate.

There are several indicators one can use to determine if turf is under stress and in need of water:

**A. footprinting:** If footprints remain in the turf or disappear slowly, the turf plants need water. When sufficient water is available, the turf will have good resilience.

**B. Use of a soil probe:** The amount of water in the root zone becomes evident in a soil sample taken with a soil probe. Dry, crumbly soil in the probe indicates water should be added.

**C. Indicator spots:** These are spots which dry out faster than the rest of the turf. The spots first turn a dark bluish-green, then orange or straw-yellow.

**D. Presence of high temperature and wind:** The combination of high temperatures and strong winds will cause plants to lose water faster than they can absorb it. Frequent light sprinkling will lower the temperature to reduce water loss.

**E. Use of tensiometers or gypsum blocks:** Tensiometers and gypsum blocks are the most accurate methods of determining the amount of moisture in the soil under field conditions. Tensiometers are most sensitive in the moist to wet soil conditions typical of intensely cultured turfs, while gypsum blocks are most effective in measuring soil moisture in the moderately dry range.



Placement of these two moisture-sensing devices is determined by the active root zone depth.

#### 4. *Uniformity of application*

Because water can easily be wasted by improperly placed sprinklers or a poorly operating underground system, water distribution should be checked. Uniformity of sprinkler coverage may be influenced by low or fluctuating water pressure, location of the sprinkler, wind direction and slope. To determine the uniformity of irrigation coverage, place three or four equal size cans at varying distances from the sprinkler. After irrigating, compare the amount of water in the cans. If the amount of water in cans varies as much as 25 percent, determine what improvements are needed to reduce the variability in coverage.

Sometimes uniformity of coverage can be improved by changing the nozzle in the sprinkler head, using larger hoses, or running fewer heads at one time. Also, by checking water distribution with a movable sprinkler, it is possible to determine the best places to set sprinklers around the lawn.

Use sprinklers that do not throw water high into the air, because this causes poor distribution and excessive evaporation. In windy areas sprinklers that deliver large droplets of water are usually efficient for watering. The spray-type irrigation heads often give poor distribution and increased evaporative loss.

#### 5. *Quality of irrigation water*

Most irrigation waters contain varying amounts of dissolved mineral salts. These may become concentrated in the soil in quantities which are injurious to grass. The probable effect from use of any water can be predicted in part from a chemical analysis. Of the items commonly determined in a water analysis, the most important for judging quality are:

**A. Total concentration of soluble salts:** This is generally the most important single criterion for evaluating the quality of irrigation water. There is a high negative correlation between total salt concentration in the soil solution and plant growth since plants do not absorb appreciable amounts of salt. Saline and alkali soils develop in irrigated areas even where drainage is adequate, unless controlled by good water management practices. If adequate drainage is provided, the excess soluble salts may be removed simply by leaching with fairly large amounts of irrigation water.

**B. Sodium concentration and its proportion to calcium plus magnesium:** The degree of sodium hazard is best expressed as the sodium adsorption ratio (SAR) which indicates sodium concentration and its proportion to calcium plus magnesium. Sodium is generally found at higher concentration in irrigation waters than any other ion, but, contrary to general opinion, it is not more toxic to most plants than calcium or other ions. In most cases the adverse effects of exchangeable sodium are seen in the physical properties of soils rather than in toxic reactions of turfgrass species. Thus, the sodium ion limits water movement through the soil (at about 15% exchangeable sodium) before it becomes a limiting factor in turfgrass growth.

**C. Concentration of bicarbonates:** As calcium precipitates, the SAR of the soil solution, and, consequently, the exchangeable sodium percentage of the soil, tends to increase.

**D. Concentration of toxic elements (boron, lithium, chlorine):** Water from many irrigation wells and from some surface supplies often contains elements such as boron, lithium, and chlorine in amounts that are toxic to most landscape plants. Turfgrasses are usually not harmed by moderate concentrations of these elements due to their removal from plants by mowing.

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# UC TURF CORNER

*Victor A. Gibeault and Forrest D. Cress\**

UC Turf Corner contains summaries of recently reported research results, abstracts of certain conference presentations, and announcements of new turf management publications. The source of each summary is given for the purpose of further reference.

## **Siduron Effects on Tall Fescues Emergence, Growth, High-temperature Injury**

Results from a University of Nebraska study indicate that siduron applications to a Kentucky 31 tall fescue seedbed can impair stand establishment, even when applied at the label-recommended rate.

This is a critical observation, note the researchers who conducted the study, since Kentucky 31 grows like a bunch-type species and lacks the ability to spread laterally. They recommend that turfgrass managers plant Kentucky 31 tall fescues as early as possible in the spring to minimize competition from warm-season weeds and to reduce the need for using siduron on the seedbed. When siduron is applied to a Kentucky 31 seedbed, they say, then the application rate should not exceed 6.8 kilograms per hectare (6 pounds per acre) and seedling rates should be adjusted upward by a factor of 10 percent.

(See "Siduron Effects on Tall Fescue [*Festuca arundinacea*] Emergence, Growth, and High Temperature Injury," by R. C. Shearman, E. J. Kinbacher, and K. A. Rierson, *Weed Science* 28 [2], March 1980.)

## **Turfgrass-paver Complex for Heavy Traffic Areas**

Vehicular traffic on turf causes wear injury and soil compaction problems that can result in stand loss and a decline in turf quality. Physical or cultural aspects that protect turfgrass crowns from wear injury enhance the turf's ability to persist in intensively trafficked areas.

Researchers at the University of Nebraska recently tested a concrete-grid system (turfgrass-paver complex) designed to protect turfgrass crowns from vehicular wear injury. The study checked the influence of this sys-

tem on establishment, quality, wear injury, and recuperative rate of six turfgrasses.

The grasses were established in the grass-paver complex in a silty clay-loam soil and were exposed to vehicular wear. The complex improved wear tolerance and the recuperative rate of all the test grasses except 'Merion' Kentucky bluegrass. That grass, 'Manhattan' perennial ryegrass, and 'Kentucky 31' tall fescue were the most wear tolerant of the grasses tested. 'Fairway' crested wheatgrass and "Highland" bentgrass fescue had the poorest wear tolerance.

The grass-paver complex adversely affected turfgrass quality of 'Manhattan' and 'Merion' but enhanced the quality ratings for 'Fairway'. Winter survival of 'Manhattan' and 'Kentucky 31' was adversely affected by the paver complex.

(See "Turfgrass-Paver Complex for Intensively Trafficked Areas," by R. C. Shearman, E. J. Kinbacher, and T. P. Riordan, *Agronomy Journal* 72 [2], March-April 1980.)

## **Thatch Influence on Mobility, Transformation of Nitrogen Carriers Applied to Turf**

Results from a University of Illinois study show that where a substantial thatch layer exists and turfgrass rooting is largely confined to the thatch layer, use of a slowly soluble nitrogen carrier might be preferable to soluble urea for reducing nitrogen losses due to leaching and volatilization.

As an alternative, say the Illinois researchers who conducted the experiment, effective measures for controlling the thatch may result in greater efficiencies in the use of fertilizer nitrogen by turfgrass.

Nitrogen leaching, retention, and volatilization were measured, using cores of thatch and Flanagan silt-loam

\*Environmental Horticulturist and Communications Specialist, respectively, Cooperative Extension, University of California, Riverside.

soil extracted from field-grown Kentucky bluegrass turf. Urea was used as the soluble nitrogen carrier and IBDU as the slowly soluble nitrogen carrier.

Application of urea resulted in 2.5 times as much nitrogen leaching and correspondingly lower nitrogen retention in thatch than in soil. Where IBDU was used as the nitrogen source, leaching from the thatch was reduced from 81 to 5 percent of the applied nitrogen, and leaching from the soil was reduced from 32 to 23 percent, when compared with urea-treated cores.

In the volatilization studies, 39 percent of the applied nitrogen from urea was lost as ammonia from thatch cores, compared with only 5 percent from the core soils. With IBDU as the nitrogen source, little nitrogen volatilization (4 percent from thatch, 2 percent from soil) occurred.

(See "Thatch Influence on Mobility and Transformation of Nitrogen Carriers Applied to Turf," by K. E. Nelson, A. J. Turgeon, and J. R. Street, *Agronomy Journal* 72 [3], May-June 1980.)

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University of California, Riverside

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Sciences Publications, University of California, Berkeley

William B. Davis, Extension Environmental Horticulturist  
University of California, Davis

Correspondence concerning *California Turfgrass Culture* should be sent to:

Victor A. Gibeault  
Plant Sciences Department  
University of California  
Riverside, CA 92521

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