Proceedings
Of The
40th Northwest Turfgrass Conference

September 22-25, 1986

Red Lion Inn

Pasco, Washington

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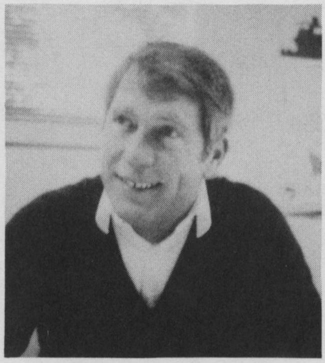
PRESIDENT'S MESSAGE



Best wishes to the Board and to our new President, Bo Hepler!

The past year has been a pleasure for me to have had the opportunity to serve the NTA Membership in this year of continued growth.

The Conference at Pasco marked our 40th consecutive conference, as we welcomed more than 40 new members into the Northwest Turfgrass Association. The Conference Supplier Show was the largest yet and demonstrated the increased commercial support for our Association; which is genuinely appreciated by all the members.

Members attending the educational sessions reported excellent speaker presentations and an interesting format of topics.

My sincere thanks to the Board for their hard work, to Dr. Roy Goss for his leadership and to the membership as a whole, for their commitment to improved turfgrass management, through our Northwest Turfgrass Association.

I look forward, as do you, to continued participation in the NTA, to the 1987 Conference at Salishan Lodge, and to the next "40 years of growing".

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RECENT OBSERVATIONS ON THE ROLE OF POTASSIUM IN TURFGRASS PERFORMANCE[1]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

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Potassium is one of sixteen essential elements required by turfgrass plants for proper growth, development and stress tolerance. Though it is an essential element, potassium is not a constituent of turfgrass tissues. It is found in plants only in the elemental form ($K+$). K enhances carbohydrate synthesis and translocation, respiration and uptake of certain other nutrients like nitrogen and magnesium. K has been reported to enhance turfgrass rooting and stress tolerance. Many turfgrass specialists have experimented for years with the potential use of K nutrition to minimize turfgrass stress.

Turfgrasses require relatively high amounts of K, perhaps even in equal amounts to nitrogen. This is particularly true in relationship to the turfgrass plant's ability to tolerate environmental stress. The term ''luxury consumption'' has been associated with certain nutrients, like K. It is well established that K can be taken up by plants in excess of their needs for growth and development. Thus, K nutrition levels can be established for pounds of dry matter produced in forages or bushels of grain produced in cereal crops. Turfgrass managers are generally not interested in clipping yields. They are more interested in maintaining adequate growth, recuperative rate, stress tolerance and playability of the turf than dry matter production. In this regard, turfgrass researchers and managers are being forced to reassess soil and tissue K levels and their critical association with turfgrass nutritional needs.

Recommendations for K fertilization are typically made based on soil tests and their resultant K index values (Table 1). These index values differ slightly with soil testing laboratories and regions. Table 1 gives indices used for Nebraska recommendations. The table is shown to simply indicate the low K levels that gave stress tolerance in Kentucky bluegrass and creeping bentgrass studies conducted at the University of Nebraska.

A drought avoidance study involving nitrogen and potassium nutrition interactions was initiated in 1976 on a Kentucky bluegrass turf. This study was terminated in 1985. Soil K levels on the site were slightly in excess of 400 lb per acre. Turfgrass clippings were removed during the course of the study. K levels ranged from 0 to 8 lb per 1000 ft^2 per season in 2-lb increments. At the end of the study, soil K levels in the 0 treatment were 380 lb per acre, which still rated high on the K index (Table 1).

Turfgrass water use decreased with increasing K levels as did turfgrass wilting tendency (Figure 1). Rooting depth and root organic matter production also increased with K levels from 0 to 6 lb. Recovery from drought injury was also enhanced by K fertilization.

Potassium deficiency symptoms are usually subtle and are not seen as easily or readily as nitrogen deficiency in turf. K deficiency symptoms often are expressed as reduced tolerance to environmental stress and diseases. K deficiencies occur most often on sandy soils that receive frequent or heavy irrigation. Daily irrigation on a Seaside creeping bentgrass green growing on a sand media rootzone resulted in soil K levels that were 20 to 30 percent lower than those of the same turf receiving the same quantity of water but in irrigations applied twice weekly. Potassium content of tissues were similar in trend to those of soil for corresponding irrigation treatments. Soil K levels never exceeded 180 lb per acre in the sandy media, even with treatments of 8 lb of K per 1000 ft^2 per season. Levels ranged as low as 30 lb per acre with the 2-lb treatment applied with frequent irrigation.

Turfgrass wear tolerance increased with increasing K nutrition from 2 to 8 lb per 1000 ft^2 per season in the Seaside creeping bentgrass study. A similar response was found for the Kentucky bluegrass study. Earlier research at Michigan State University found increasing turfgrass wear tolerance with K rates ranging from 0 to 8 lb per 1000 ft^2 per season on a Toronto creeping bentgrass green growing on a rootzone of 1 peat: 1 soil: 1 sand. In the Seaside creeping bentgrass green study, wilting tendency and water use were found to decrease with additional K. A reduction in pink and gray snowmold activity was found for treatments receiving 4 to 8 lb of K per 1000 ft^2. Desiccation injury declined significantly for turfs receiving 6 to 8 lb of K per 1000 ft^2. A similar trend was found in the Michigan study which was conducted in 1969.

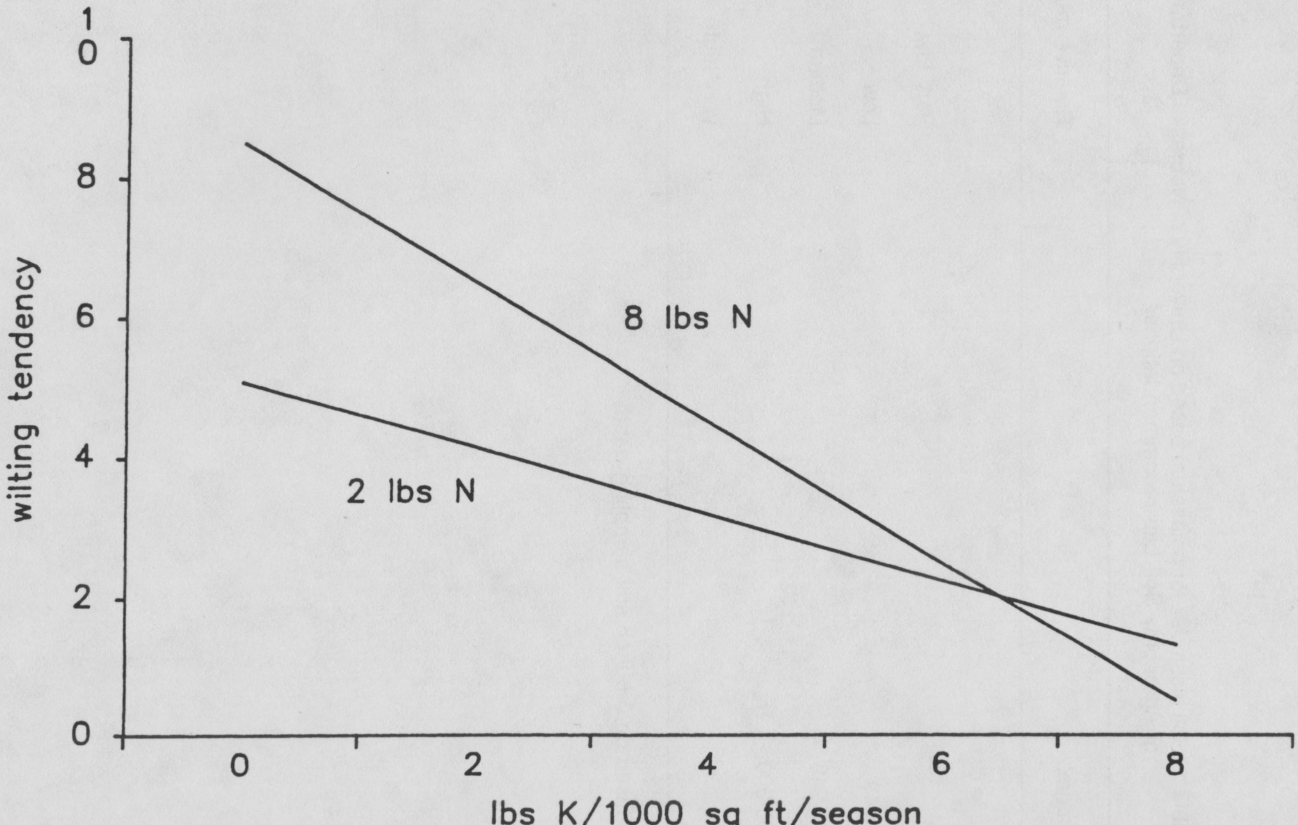
On sandy soils with low water and nutrient retention capabilities, it is best to apply potassium in light, frequent applications rather than infrequent, heavy ones. This procedure ensures more uniform use of the K, rather than allowing it to move rapidly out of the effective rootzone. This situation is particularly the case when frequent irrigation is also required to maintain desired turfgrass quality.

There is growing evidence for the benefits of K nutrition in minimizing turfgrass stress. Turfgrass managers should use this information to help maintain desirable turfgrass quality and playability. K is not a miracle element. It is an essential nutrient and turfgrass managers should keep its role in perspective. Applying excessive amounts in relationship to other nutrients may result in severe nutrient imbalance problems. A fair amount of evidence exists to support the use of increased rates that approach ratio of 1 nitrogen: 1 potassium for enhanced stress tolerance. A concerted research effort is being conducted at the University of Nebraska with potassium. This research is being supported in part by a grant from the United States Golf Association Green Section.

Table 1. Soil test index for potassium based on University of Nebraska Department of Agronomy Soil Lab recommendations.*

K-index	Relative rating
(lb/acre)	
80	Very low
81-149	Low
150-249	Medium
250-300	High
301	Very high

* Based on 0-6 inch soil sampling depth.


wilting tendency
10
8
6
4
2
0
8 lbs N
2 lbs N
0
2
4
6
8
lbs K/1000 sq ft/season

UNDERSTANDING LIME AND ITS EFFECTS ON SOIL AND TURFGRASSES[1]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

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Soils in the Pacific Northwest are extremely variable with respect to soil pH. Soils in western Washington, Oregon and British Columbia are highly weathered (leached) generally due to high rainfall during winter months. Through the process of weathering, calcium and magnesium which are supplied by lime are leached to deeper strata and the surface soil continues to increase in acidity. High rates of nitrogen can also increase the acidity through leaching of calcium. A large number of hydrogen ions are contributed from the breakdown of several nitrogenous compounds which cause this effect.

WHAT DOES LIME DO FOR YOUR SOIL AND PLANTS?

Many plants have a rather specific pH value for optimum growth, development and yield; however, turfgrasses can generally tolerate a rather wide pH range.

1. Lime is a source of calcium and/or magnesium to be used as plant nutrients.

2. Lime raises the soil pH.

3. Lime reduces excess amounts of aluminum and/or manganese. Both of these elements increase in concentration as soil pH lowers, particularly on many medium to heavy textured soils.

4. Lime increases the availability of phosphorus. Aluminum and manganese levels can become high at low pH values. Under these conditions, aluminum is chemically very active and may combine with phosphorus rendering it insoluble and unavailable.

5. Lime reduces potassium leaching. At low pH values, aluminum can replace potassium on the soil colloids and allow potassium to leach below the root zone. This is particularly important on sandy soils.

6. The most economical source of magnesium. Dolomitic limestone will supply magnesium very inexpensively. This source of liming material will supply both calcium carbonate and magnesium carbonate. Due to a slow release of the magnesium from this liming material, it is less subject to leaching than many other

magnesium sources.

7. Lime increases available molybdenum by raising the soil pH. Although molybdenum is a micronutrient, it is still required by grasses even though in small quantities. Most of the micronutrients are more soluble and available at lower pH values than that required for molybdenum.

8. Lime improves soil aggregation; hence, an increase in air porosity. Calcium derived from the calcium carbonate in lime is the active agent in causing soil aggregation. Gypsum is frequently used for improvement in soil aggregation or soil structure. If an increase in soil pH (lowering of soil acidity) is required, then agricultural limestone or dolomitic limestone may be a better and more economical choice than gypsum. If, on the other hand, no soil pH increase is desired, then gypsum will supply calcium for the purposes of aggregation without raising the pH level.

9. Excesses of lime can raise the pH of soils and this can result in reduced availability of phosphorus, iron and most of the micronutrients.

Soils in the interior of Washington, Oregon and British Columbia and eastward are generally well supplied with calcium and magnesium since these soils are not highly weathered as a result of low precipitation. It should be pointed out, however, that under irrigation and high use of nitrogenous fertilizers, calcium and/or magnesium can be leached from these soils and they can become quite acid.

WHAT DETERMINES THE RATE OF REACTION OF LIME IN THE SOIL?

The rate of reaction of liming materials in the soil and its subsequent effect on soil pH is directly related to the lime particle size. Finely ground liming materials (100 mesh or finer) react very rapidly and will significantly raise pH. Coarse materials from 8 to 20 mesh are of little value and have essentially no effect on soil pH over a long period of time. Liming materials ground as fine as 100 mesh produce responses in pH change more nearly equal to that expected from the application of calcium oxide (burned lime) or calcium hydroxide (slaked or hydrated lime).

Since the neutralizing efficiency of lime is related entirely to the fineness of grind, this should not be confused with neutralizing power. The neutralizing power of pure calcium carbonate is accepted as the standard and is arbitrarily set at 100%. The neutralizing power of most products used consistently for correcting soil acidity ranges between 75 and 105; hence, they will neutralize from 75 to 105% as much acid as an equal amount of pure calcium carbonate. Values of 100 or over are usually obtained with limestones containing substantial quantities of magnesium carbonate. Inert materials in lime will account for neutralizing power of less than 100. Inert materials can include clay, sand, silt and organic matter and other foreign materials.

TYPES OF LIME AVAILABLE

High grade calcium carbonate can be referred to as calcite or calcitic limestone. This material contains essentially no magnesium. A mixture of crystalline calcium/magnesium carbonate is called dolomite when the calcium carbonate and magnesium carbonate occur in equal proportions. In other proportions they are said to be dolomitic limestone (those containing less magnesium).

FORMS OF LIME

1. Agricultural limestone. This is the most widely used liming agent and, in a finely divided state, is one of the most useful liming materials. To be sold as agricultural limestone in the Pacific Northwest, there must be a minimum guarantee of calcium carbonate equivalent and must meet minimum screen sizes specified by state departments of agriculture.

2. Granular lime. The terms "granular" or "pelleted" lime are used interchangeably. When very small particles of agricultural limestone are combined with a binder to produce larger granules, they are easier to spread, dust-free, and generally are of uniform size. These granules disintegrate with moisture and react the same as other liming agents. Most of these pelleted materials are very fine and may actually release quicker than standard agricultural limestone when surface-applied. We should not, however, confuse the rate of reaction with the neutralizing power. Some users believe that pelleted limestone will neutralize more acidity than the same amount of ordinary agricultural limestone. This may be true if the agricultural limestone is between 8 and 20 mesh. It has already been pointed out that lime particles between 60 and 100 mesh have essentially an efficiency rating of 100%.

3. Liquid liming agents. There is a relatively new process whereby standard agricultural lime is suspended with the use of kaolinitic clay to make a fluid material that can be uniformly spread on the soil surface. The advantages of this material is that relatively small quantities can be applied per unit area and all dust is eliminated. Some sales representatives claim that these materials change the pH very rapidly. This is so only because the particles that are suspended have been finely ground. Approximately one-half of the product's weight is water. Therefore, for example, 1000 lb of the suspension may only contain approximately 500 lb of liming material. Liquids or lime suspensions must be evaluated upon their calcium carbonate equivalent content to determine their neutralizing power.

4. Calcium oxide. This product is known by several names including unslaked lime, burned lime or quick lime. It is a white powder that is extremely caustic and will corrode machinery. It is manufactured by roasting calcitic limestone in an oven or furnace, eliminating carbon dioxide and leaving calcium oxide. Its purity is determined by the purity of the raw material. Calcium oxide, in its pure form, has a neutralizing value or calcium carbonate equivalent of 179%.

5. Calcium hydroxide. This material is frequently referred to as slaked or hydrated lime. It is quite similar to calcium oxide since it is a white, powdery substance and is both difficult and unpleasant to handle. Soil acidity is rapidly neutralized by calcium hydroxide. Slaked lime is prepared by adding water to calcium oxide. A great deal of heat is generated when water is added and when the reaction is complete, the material is dried and bagged for shipment. The chemically pure compound has a neutralizing value of 136 and is second to calcium oxide as a neutralizing agent.

A number of other materials may be found available on the market from time to time which would include lime sludge, which is a byproduct from the paper manufacturing process. Some of these materials can have a calcium carbonate equivalent of 95%. Kiln dust is a byproduct of cement manufacturing. Kiln dust may have a calcium carbonate equivalent value of 80 to 85% and carries a good level of potassium as well. Fly ash is a fine product trapped by electrostatic precipitators when pulverized coal is burned in electric power generating stations. It is extremely variable in its calcium carbonate equivalent. There are several different slags that may be locally available. Blast furnace slags vary from 75 to 90% in calcium carbonate equivalent and can contain appreciable amounts of magnesium. Basic slag contains calcium silicate with approximately 60 to 70% calcium carbonate equivalent and is also a reasonable source of phosphorus. Electric furnace slags may have a small amount of phosphorus and have a neutralizing value of 60 to 80% of calcium carbonate.

LIME REQUIREMENTS FOR ESTABLISHING TURFGRASSES

To determine if your soil needs lime, check both the pH and the calcium level of your soil test report. Use the table below in the following manner: In the left hand column find the pH range corresponding to your soil. Across the top of the table find the calcium range for your soil. Go down this column until it intersects the line covering the pH range into which your soil falls. The number at the point of intersection is the number of pounds of lime to apply for each 1000 ft^2. For example, if your soil has a pH value of 5.8 and a calcium value of 4 meq/100 gm of soil, the amount of lime to apply is 125 lb per 1000 ft^2.

Just remember that for neutralizing efficiency, the fineness of grind will influence the rate of acid neutralization. In general, lime that is ground fine enough that 90% passes through a U.S. Standard No. 8 sieve and at least 20% through a U.S. Standard No. 100 mesh sieve is satisfactory. Liming materials, then, should be worked into the upper 4-6 inches of soil well in advance of fertilizing and planting.

For liming established lawns, no more than 50 lb of agricultural limestone or dolomitic limestone should be applied per 1000 ft^2 per application. In general, it is much more desirable to apply 30-35 lb per 1000 ft^2 and repeat once or twice annually until the desired pH and/or calcium content has been achieved.

The table is taken from Washington State University's FG-41, Fertilizer Guide for Home Lawns, Playfields and Other Turf, and may vary somewhat from other states but will, no doubt, correlate very closely.

In conclusion, just remember that liming materials are based upon their calcium carbonate equivalent and regardless of whether they are powders, granules, suspensions or sludges, they all work the same way except fineness of grind will influence the rate of reaction.

Lime for new lawns

	If Washington State University soil test for calcium (Ca) in terms of meq/100 g soil is:			
pH Value	Below 2.0	2.1-3.5	3.6-5.5	above 5.5
	(lb of lime/1000 ft^2 to apply)			
4.0 - 5.0	100	150	200	200*
5.1 - 5.5	100	125	150	200*
5.6 - 6.0	75	100	125	0
6.1 - 6.5	50	50	0	0
above 6.5	0	0	0	0

* Lime rates over 200 lb/1000 ft^2 are not needed. The undesirable chemical condition is adequately corrected for grass by this rate, even if there isn't a major increase in pH.

ALL THE WAYS WE KILL A PLANT[1]

Robert E. Partyka[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
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Green foliage during the warm months of the year generally signifies healthy, growing plants. To the casual observer this is usally true in most cases, unless there has been widespread devastation that makes it obvious that something is wrong with the plant material. Extensive destruction of foliage or death of plant material in a short period of time often becomes noticed; mainly because it occurs, relatively speaking, in a short time span.

Gradual changes often go unnoticed because they occur slowly. Therefore, the day-by-day observations really do not signify any outstanding symptoms that the novice can detect until suddenly a very obvious problem exists. Logic dictates that the occurrence is sudden, but an understanding of plant physiology suggests otherwise.

As plantsmen, we should be attuned to the subtle changes that occur with time in plants under our jurisdiction. These changes often signify a reaction of the plant to its environment. By observation and investigation we should be able to determine the nature of the change and whether a remedial measure is warranted or practical. The nature of these measures will vary depending on the particular problem.

Determining the nature of the problem is often most difficult because case histories are not usually kept on plants. Often ''happenings'' insignificant at the time are not reported or noted but can play a deciding role in the health of the plant because they contribute to some other so called ''minor incident''. Each situation alone may be independent, and the plant will recover if given sufficient time. On the other hand, several minor problems or stress situations occurring in a short time span may have a synergistic effect and result in rapid decline of the plant.

What are some of the factors that may lead to plant decline? How are we encouraging plant decline in our modern day society? What should we be looking for and making others aware of the repercussions when something is done to a plant? We will try to cover some of these points in this discussion.

Plant Production Area. A logical place to start will be at plant origin. Plant production areas are regulated by each state to produce sound, healthy plants. However, as new introductions are brought into the trade, new problems often develop that were not present in the early development stage. These problems are often difficult to trace back, and in the case of some diseases may be almost impossible, because of other conditions that may encourage the organism at the final growing site. Cultural or chemical growing conditions that suppress an organism can produce an apparently normal healthy plant only to have it fail at a later date when subjected to a different growing regime.

Plant production practices may be aggravating the girdling root situation with the advent of artificial media and container grown plants. If the time span is too long in the container, roots are distorted and are often put into the soil in that fashion. In time, distorted roots may lead to a girdling root problem at a low soil level which is most difficult to detect on an older plant. Specific handling instructions of these types of plants at the time of transplanting will often remedy the situation and prevent a problem from occurring in the future as the plant matures. The question arises as to communicating this message to plant installers.

Landscape Design. Landscape design for now or the future must be carefully thought out when selecting plant material. Too often plants are selected for an immediate visual impact which certainly cannot be neglected. But if the plant material is to remain permanent and develop into the future, soil, climate, size and area usage must be carefully thought out before planting. A life expectancy needs to be placed on the landscape and all environmental ramifications should be considered before plants are selected to avoid future problems. Unfortunately, the physiology of a plant is often not taken into consideration in many situations before assigned a place in the landscape design.

Handling Practices. Handling practices of plant materials in transit, storage and at the planting site are important considerations for survivability. Improper watering practices that fail to soak the root ball and provide water to the inner area may be a factor in plant losses. Burlap coverings or similar materials often restrict water movement into the ball and plants can be suffering from a water shortage because of this barrier effect. While mulched and with good watering practices, the survivability of such plant material is often much lower due to physiological stress, even though visual appearance may not be altered.

The mechanical fracturing of the root ball and breaking roots by dropping is of concern with some plants. On the other hand, this type of handling may be more appropriate for pot bound or container grown plants to help break some of the roots for a better distribution pattern. Tightly bound roots need to be cut to re-establish a better rooting pattern. This appears to be an increasing problem with containerized planting stock. Again, a lack of communication appears to be involved.

Standardized transplanting procedures for most plant material are well outlined in the literature. The major concern is whether the practices are followed properly and whether the transplant crews have had a review of these proper procedures prior to the planting period. At times, there appears to be an information dissemination gap between the individuals doing the work and the ones hiring them. Better training in this area or more on-site supervision will certainly help in reducing plant problems in future years.

Transplanting. Many new ideas and practices have been explored in the transplant area. Some have been very helpful while others have created problems. Old practices are being re-explored to see if they are valid and how they influence plant growth. Transplanting procedures that can lead to future problems are many and each must be carefully considered at the time of planting.

Balled and burlapped plants are still used and should be handled carefully. One has to presume that all the roots are intact since it is not practical to tear the ball apart. How many plants fail because of a lack of roots due to a skewed root system, or the ball is too small resulting in poor water and nutrient absorption. Standards have been developed for root ball sizes and should be adhered to when selecting plants.

Balling materials and twine must be of sufficient strength to keep the root ball intact, but once planted decompose to prevent root bound or girdling problems at a later date. Plastic and nylon have been the culprits in many situations, when not removed and when buried under a mulch to retard photodegradation.

New mechanical equipment has given us the capability to move many plants into specific locations. Minimum soil and root disturbances, when done properly, should provide for better plant survivability. However, size and age of root systems on the plant, the transfer from one soil type to another, improper placement depth, soil settling, and soil glazing have been factors in plant decline, often many months after the movement. Reserve carbohydrates in the plant often allow it to remain alive for an extended period of time, often lulling one into believing it is growing well only to find the plant eventually fails. Practices to improve establishment percentages need to be followed carefully. Improper use of mechanical equipment can result in damaged tissue that will callus slowly; thus opening the way to borers and canker diseases until the plant is vigorous enough to overcome the injury.

Planting depth and soil oxygen, as well as other gases, are important factors for root growth and development. How often do you find plants too deep in tight soils? They often survive for a period of time until some other apparent minor problem develops and the added effect is disastrous to the plant. Settling of the plant ball as well as the disturbed base soil are often associated with the plant being too deep. One can say that porosity of the original root ball soil is the same, and this may be true if the area is not covered with something, such as deep mulches, to change the air exchange capacity. However, roots established at one live in a soil type may not respond well when planted in a different gas exchange level of another soil type; therefore, roots may not expand out into the surrounding soil rapidly enough to take care of the top foliage needs.

Water and watering practices are part of transplanting procedures. Soils of low permeability will hold more water and affect gas exchange. Therefore, we see the need and often do establish plants at a higher level to provide a better area for root development if we cannot modify the soil or the water table. Of course, natural climatic factors of excess rainfall may come into play at times and aggravate the situation. Guarding against excessive soil moisture is an important consideration in poorly drained areas.

Watering frequency after planting is important as it ties in with the soil site and root ball. Frequent watering of a porous soil ball may result in water accumulating at the base of the root area, drowning lower roots but keeping the top roots too dry. This problem is often evident with the newer lightweight plant mixes. On the other hand, water applied rapidly to a tight root ball can result in water moving around the ball so the inner root system still remains too dry. Proper development of the finished top soil and root ball area can direct the water to the best location. This soil must be structured before a mulch is placed on top.

Plant Size. The proper sized plant as compared to its survival capability needs to be considered in each location. What should one expect in future growth patterns? Large plant material, improperly handled, often results in a poor specimen that may take years to become fully established under the most ideal conditions. Smaller plants with better recuperative capabilities may be a better choice in the long run. Top to root ratios must be considered on most plants.

Wire cages and twine needed to move the plant and establish it must be watched to prevent girdling and loss of the plant. Thus, some time schedule should be established to look after the plants to insure that these materials do not become detrimental in the long run.

Soil Disturbances. Mechanization and the capability of moving and molding the earth associated with modern progress has resulted in many plant related problems. Unfortunately, many of these problems do not develop until long after the initial work has been done in the area. Lack of records or people not familiar with the area makes it difficult to diagnose the problem. But construction stress as related to the specific plant and the particular site, coupled with other minor stresses, is common in most urban areas and can explain many, if not most, decline problems.

Deep cuts and root pruning is often obvious in an area of established plants. A question always arises whether such plant material should even be saved when subjected to installation of water and sewer lines below the surface, black topped roads on the surface, a possible shift of the water table coupled with reflected heat and automobile exhaust fumes. The cost of maintenance and removal of a dead plant could be used in establishing a new plant or plants to develop in the newly changed environment.

Fills, when done properly, often do less damage to the plant. The problem with a filled area is that often other subsurface soil disturbances may occur or water tables can change that eventually become the primary factor in plant decline. Individual plant reactions to changing gaseous soil levels are important to the root system.

Mechanical Damage. Mechanical damage to the trunk is often taken for granted and is considered a way of life with modern mechanization. Too often a plant is put into the same class as an inanimate object that can be abused within reason and still perform. This is not the case, and if more people would consider someone kicking them in the shins or using a weedeater on their ankles at very regular intervals, possibly less damage would occur. Wounds pave the way for secondary organisms that can further weaken the plant and result in death or removal.

Proper pruning techniques have been well published, but power equipment has, in some cases, resulted in poor pruning techniques that favor slow wound healing. This, in turn, has given rise to internal rots and structurally weakened limbs of trees. Training aids of a visual type, plus demonstrations, can certainly help in this area.

Mulches. Mulches have been used in recent years to control weeds, conserve moisture, prevent mechanical damage to plant material, and to provide for a more pleasing look in the landscape. Due to rising costs and availability in an area, various ways have been found to reduce costs and still provide weed control. Some of the new ideas and techniques have resulted in plant problems. Basically, we need to be cognizant of downward movement of water and air, upward movement of water vapor and toxic gases, and the role of the mulching material on the root and lower stem microclimate. Solid plastic film barriers often redirect water to the root area resulting in excessive water, oxygen exclusion and dead roots. This appears to be more of a problem in heavy clay soils and sloping areas where water moves to the lower level. Perforated plastic film or narrow strips placed in a manner to allow for better water penetration will help. However, gas exchange may still be a factor. The newer mesh weed barriers are improvements over the sold plastic film.

Deep, organic mulches, accumulating because of added layers used for aesthetic purposes, can result in low evaporation rates and result in a water-logged soil that favors low oxygen levels and root rot organisms. Deep mulches can also reduce stem tissue acclimatization in the fall in northern areas and favor low temperature damage of the lower stem tissue. Density and texture of the mulching material used around the plants is important in such cases.

Soils and Soil Compaction. Soil compaction may be an important factor in many areas. The use of heavy equipment to move soils under less than ideal conditions destroys most soil structure. In addition, soils of the B and C horizon with a clay base, or in some cases certain size sand particles, tend to pack tightly and may create an artificial barrier. Topsoil, placed over this packed layer, allows plant roots to establish in the upper soil layers. But if water permeability is restricted due to the artificial hard pan, a high perched water table may become established and drown out the root system. Deep subsoiling may fracture the soil prior to planting and allow for water and gas movement. However, once settling reoccurs, permeability may be reduced and result in water accumulation around established roots.

Soil compaction from pedestrian traffic patterns under various weather conditions may be a factor around established trees. Moist soils in a pliable stage can be compacted more readily than dry soils. Thus, some foot traffic control may be needed in areas of extensive tree root systems.

Grade changes to move water away from buildings is necessary to reduce moisture problems in the building. However, the rapid movement of surface water affects penetration and percolation, especially in turf areas that often become thatch bound. Plant material in these locations must be able to cope with low water requirements, or else the area designed in a fashion to facilitate good water penetration into the soil.

Pesticides. Numerous chemicals have become important items in our ability to provide the needed feed, food and fiber to sustain man and provide him with opportunities to be more productive. Increased productivity has provided for more leisure time. This leisure time has resulted in a greater demand for recreational development, a need for a pleasing and relaxing atmosphere and has created more opportunities and challenges for the ''green industry''.

Many of these same chemicals are used in the green industry to reduce man hour inputs and most have performed very well when properly used. As with any chemical, problems have occurred when directions are not followed, equipment is not calibrated or accidents occur. In some cases, all the ramifications of a material are not known and certain weather patterns may influence their behavior and performance.

Herbicides. Chemicals or compounds in the soil are at times very difficult to determine because of the many factors that influence them. The growth regulator materials so often used on turf generally are broken down readily by soil organisms and do not last for any appreciable time. However, some can move in soil water and may locate in lower soil levels where biological activity is lower; thus, they may remain for a longer period of time and exhibit typical leaf and parallel venation symptoms at some later date when the plant is subjected to a stress condition. In general, the growth regulator compounds often exhibit rapid symptoms on the plant because activity is so closely related to normal physiological processes in the plant. But, for the most part, healthy tolerant plants such as woody ornamentals are capable of overcoming these materials. Granted, continuous use at abnormal rates will weaken the plant and result in decline or death.

Non-mobile chlorophyll inhibitor chemicals used at proper rates have played an important role in weed and grass control. Excess rates will result in definite yellowing of the foliage. The degree of damage and reduced carbohydrate accumulation often determines the survivability of the plant.

Mobile chemicals or persistent soil sterilants should never be used in the vicinity of woody ornamentals unless the purpose is to eliminate the plants. Soil cracks, worm holes and frost action may result in the persistent material coming in contact with stem or root tissue and eventually damaging the plant.

Newer foliage applied weed control compounds on the market that are soil deactivated must be used with caution because symptom patterns may not appear until a year later. This appears when materials are misdirected to green, woody stem tissue or direct contact is made to shallow growing roots in turf.

Oil or gasoline spills during construction resulting in a contaminated soil can explain some plant decline. Buried material is often difficult to detect and may require extensive digging and testing to determine the hydrocarbon culprit.

Soil Gases. Soil gases are important to plant roots. The proper level of oxygen is necessary for root development. If the level becomes too low, root function ceases and top decline becomes evident. Leaks from gas and sewer lines are often present in areas and, if one has a keen nose, it may often be detected in the area. Unfortunately, severe root damage has often taken place by the time the foliage responds and plant survivability may be questionable.

Soil gases associated with excess soil moisture in poorly drained areas is common in local areas. This often relates to watering practices and general water movement. One has to be aware of the grade and where water accumulates and also if irrigation is utilized in the area. Often water systems are designed for turf and not woody plants, resulting in saturated soils around trees. Two systems are often needed in these cases for best utilization of water and growth of the plant material.

Salts. Chemical salts in roadway use have been recognized by most folks living in northern climates when we look at our automobiles. Aerial drift onto plants along roadways and some beach front properties with soil salt accumulation is very evident in some parts of the country. The selectivity of tolerant plants must be considered for the location if it is impossible to limit the use of salt in an area.

Insecticides/Fungicides. Foliar applied pesticides for insects and disease control can result in plant damage if rates are too high, too many combinations are used, oil based compounds are utilized, temperatures are too high or too low, or plants are in a stressed condition at the time of application. Following label precautions, state recommendations, proper mixing procedures and keeping good records is the best advice one can follow. There are many variables that come into play each year and possible damage may occur from time to time. One of the most fortunate things about foliage damage is that plant material will recover if it is in a healthy condition. A weak plant may be stressed to the point that it may fail to recover the following year. Another reason for good records.

Air pollution, as a factor of industrial progress, is part of man's doing. Some of the chemical pollutants are new but many have been around as long as the earth has been in existence. Man's development and concentration has allowed these materials to accumulate in certain areas and, thus, the problem on plants. Recognizing specific symptoms and looking at more tolerant plant species will be a factor for the future as industry copes with abatement devices.

We can't ignore man's introduction of certain insects and diseases into an area. This has been evident by the gypsy moth in the east, Dutch elm disease on our American elms, to the isolated plant with an insect problem in an area of the country where the pest is non-existent due to the nature of climatic conditions.

One more area of great importance needs to be considered, and that is climatic changes that take place in varying cyclic patterns. Short cycle patterns are often easily recognized, but the 40-50 year cycles are difficult to remember unless accurate records are kept. These long term patterns are extremely important in determining why certain plants fail after growing for so many years in one location. A long time to us is minuscule in the geological time span.

We talk in terms of an average life span of a plant. Do we really know how long that plant will survive when placed in an urban environment and subjected to man's constant manipulation? Essentially, the fate of urban plants is in our hands and what we do to them. We should follow all precautions possible to insure the survival of the plant material. We must also recognize that based on past experience, plants will not survive if certain practices are employed. Therefore, let us benefit from past experiences to determine the future and stop repeating the same mistakes. Accept plant material for the way we have treated it and recognize that it may have to be replaced because of our own mistakes.

WILL GROWTH REGULATORS EVER WORK FOR US?[1]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

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Currently, vegetation is largely controlled by mechanical means which are costly, labor intensive and, in numerous cases, dangerous to both the operator and the bystander. Thus, herbicides have been used for many years for the control of unwanted vegetation. Yet, as more emphasis is placed on the survival and acceptable appearance of grass species, growth regulators are increasing in value for vegetation management. To choose the proper chemical for controlling vegetation requires classification of 1) the relative value of various turf areas, and 2) the costs of achieving the desired value.

CLASSIFYING TURF AREAS

In order to know where to use available growth regulators to assist in mowing, the managed areas must be classified. Figure 1 shows a classification scheme as a method of describing relative levels of management.

Class A turf is that receiving high levels of input. Mowing is done on a frequent basis to maintain a groomed appearance at all times. Fertilizers are usually applied 2 to 4 times per year. Pests are generally controlled on a curative program and the areas are often, but not necessarily, irrigated. Examples of Class A turf include golf greens, tees and fairways, sportsfields, high quality home lawns, and improved sections of industrial grounds parks and cemeteries.

Class B turfs are those that for reasons of aesthetics need to be mowed on a frequent basis but generally do not have other inputs. They key objective remains control of vegetation height as in Class A turfs. Perhaps once a year or every two years, these areas are fertilized and broadleaf weeds are controlled. Mowing frequency is equal to that for Class A turf when based on the growth rate of the turfgrasses, but may be slightly less based on calendar days. Examples of these areas include the major portion of industrial grounds, parks, cemeteries, golf course roughs, and home lawns.

Class C turf is mowed 2 to 3 times per year, usually never fertilized but control of certain broadleaf weeds may occasionally occur when infestations become severe. The key objective with this mowing frequency is to cut off seedheads which result in brown color and excessive vegetation which may harbor unwanted animal life.

An example of this type of turf area would be roadside turfs adjacent to the highway.

Class D areas can no longer be called turf and the mechanical or chemical brush and weed control cannot truly be called mowing. Vegetation control along these areas is usually done with a "brush-hog" or chemicals known as "total veg" control materials. Examples of this class include railroad and power line rights-of-way as well as the more obscure parts of highway rights-of-way.

CLASSIFYING CHEMISTRY

There are numerous ways which vegetation management chemistry can be classified, and soil and plant residual action is one way (Figure 2). Certainly there are advantages of products that have a short residual action, those with long residual action and combinations of both. The key part of my discussion today centers on amidochlor, the proposed common name for the product sold under the trade name of Limit. Amidochlor has also been researched under the MON-4621 code number. As shown, amidochlor has the shortest life in the turfgrass biosphere (structures at end of paper). Amidochlor will slow vegetative growth for a period of six weeks and control seedheads of cool-season grasses if applied prior to seedstalk elongation. The biological effect seems to outlast the chemical effect as the plant reorganizes meristems toward vertical growth. Thus, the rapid loss of amidochlor from the biosphere provided a unique tool to study growth and development of cool-season grasses.

As with many other growth regulators, amidochlor will not discolor rapidly growing, non-vernalized turf. In fact, a darker green color results in suppressed tissue, although some natural tip dieback occurs as the leaves age beyond their natural life. Yet, in the field many examples of off-color were reported with the product.

It was proposed that certain physiological processes of turfgrass growth and development were obscured during the revolution of turfgrass science and management that occurred in the 1950's. Briefly, development of efficient mechanical mowers and fertilizers designed specifically for turfgrass resulted in a rapid improvement in the ease of maintaining aesthetic quality in large acreages of turf. Turfgrass research on the life-cycle of cool-season grasses, particularly on the seedhead or reproductive phase, more or less ended at that time as these processes could be rather easily obscured through mowing and other management practices.

For years researchers have said that mowing results in a series of developmental and physiological processes in the plant such as synthesis of the growth hormone ethylene at the cut end of leaf blades and subsequent stimulation of tiller development. It is now believed that these processes currently associated with mowing are again altered when the practice of mowing is reduced or eliminated. It is further believed these processes are important in describing a large part of the erratic turfgrass response to growth regulators both in turfgrass quality alterations and in growth suppression. The processes are involved in the annual life-cycle of perennial cool-season grasses which result of natural leaf aging, senescence and death.

It is proposed that descriptive stages of spring development be identified to provide for better markers of proper application timing and interpretation of PGR results. Research and observations at Monsanto have led to conclusions presented here that indicate the response of grasses to PGR's can vary from excellent growth suppression with little or no turf quality loss to poor growth suppression with severe turf quality loss.

STAGES OF SPRING GROWTH

Figure 3 outlines the annual life-cycle of cool-season grasses and identifies proposed growth stages: I) cold dormancy; II) green-up; III) rapid vertical growth; IV) reproductive physiology; V) revegetation; VI) heat and drought dormancy; and VII) fall revegetation. Since spring is the preferred time of application, only the first five stages are discussed.

Stage I. Dormancy or Pre-greenup. Pre-greenup is the appearance of the turf immediately following loss of snow cover. The appearance varies according to the kind of grass, the quality (color) of the turf the previous fall, and the severity of winter effects. Within days after the snow melts and under full sun, existing leaves that were not excessively damaged from winter effects will green up through chlorophyll synthesis. Leaves damaged beyond repair remain brown and fully visible until warmer temperatures hasten their degradation.

In certain areas along the west coast and mid-Atlantic east coast of the United States, winter temperatures are mild and cool-season grasses only partially brown off. In this case the pre-greenup stage does not occur.

Stage II. Greenup and Initial Growth. As temperatures begin to warm, new leaves grow from the crown apex (growing point) within existing leaves. Older leaves degrade and are replaced by new leaves. This process, known as greenup, may occur over a period of several weeks depending on how fast soil temperatures rise. If this stage is prolonged by continued cool temperatures, the turf may reach 100 percent greenup while achieving only minimal vertical growth.

Stage III. Rapid Vertical Growth. The beginning of Stage III is most easily characterized by the need to mow. The grass is beginning to grow so fast that weekly mowings often remove much more than the recommended 1/3 to 1/2 of the existing leaf height. If spring season temperatures warm rapidly and consistently, this stage can be entered before 100 percent greenup, and more than one mowing may be required before complete greenup has been achieved.

Near the end of this stage, the seedhead forms at the stem apex. The developing seedhead can be felt as a bulge at the base of the leaves. A number of plants need to be examined since not all will develop a seedhead each year. For verification, the leaves can be stripped exposing the young seedhead approximately 1/8 inch in diameter and 1/2 inch long. Stage III ends when the first young, short seedheads appear in the turf area. While it is too late to control those seedheads, a high number of later forming seedheads can still be controlled. The duration of Stage III appears to vary according to climate and weather, but usually lasts 2-3 weeks.

Stage IV. Reproductive Physiology. In this stage, the seedstalk below the seedhead has begun to elongate. In many cool-season grass species, about the time the seedhead becomes visible in a mowed turf, a natural plant hormone (signal) causes the leaves on the tiller that bears the seedstalk to stop growing and provides nutrients and energy to the developing seedstalk. Thus the plant is under the effect of a natural, internal plant growth inhibitor.

At this time a signal (perhaps the same one) causes the lateral buds to start developing into tillers at a faster rate and to form a new crown apex. The aging leaves associated with the seedstalk discolor, senesce and die as the young tillers grow and expand.

Stage V. Revegetation. The turfgrass sward eventually replaces all the original plants through rapid growth of new tillers. The dead plants degrade and fall into the thatch. Thus, the green color of the lawn is maintained through development of new crown apices and new leaves.

LIFE-CYCLE VARIATION AMONG SPECIES AND VARIETIES

Normally this transition (life-cycle) occurs in a lawn with minimal disruption of turfgrass quality. Grass varieties or species that have difficulty maintaining quality during transition are referred to as the ''stemmy'' types.

In the cool-season region, May and June are known as the stemmy months for the stemmy varieties. Turfgrass researchers have known that the grasses are not attractive during the stemmy phase and many turf managers have also recognized that certain varieties have stemmy characteristics in May or June. However, while stemmyness seems to be well known, it has not been well researched.

For many years turfgrass researchers have suggested that the key improvement of the Kentucky bluegrass varieties is improved resistance to *Drecshlera (Helminthosporium)* leaf spot diseases. Leaf infections int he spring are thought to translate into the severe ''melting-out'' turf losses which become most evident in the common varieties.

However, university researchers and turfgrass seed company researchers have also known that one of the major differences between improved and common Kentucky bluegrass varieties is the ability to produce seed. Common varieties produce copious amounts of seed and many of the improved varieties are very poor seed producers. As an example, the variety, Sodco, was very attractive in the vegetative state in the lawn, but failed to produce enough seed for marketing. It is proposed that the severe turfgrass quality losses from the melting out phase in common Kentucky bluegrass are primarily a result of reproductive senescence of the leaves associated with the seedstalk and the leafspot organism invades an already weakened plant.

Variation among species and varieties, in relative ease or difficulty living through reproductive transition appears to be associated with two factors: 1) the overall tendency of the species or variety to produce seedheads (percentage of the plant apices with potential to flower), and 2) the tendency of those plants to follow through with the flowering physiological state in spite of the mowing regime imposed on them (seedheads regularly mowed off).

It is recognized that the more recently developed varieties, such as Baron, are both "improved" and have excellent seed production. It is suggested that the mowing regime is quite effective in preventing these varieties from going through the destructive flowering physiology stage.

As a cool-season species, tall fescue is best adapted to the transition zone of the United States largely due to summer survival. Yet unmowed tall fescue develops a seedhead, matures and browns off while mowed tall fescue remains green. Thus, it is suggested that a major contribution to summer "tolerance" of tall fescue is the fact that frequent mowing removes the seedhead before natural hormones kill the leaves and a portion of the roots.

CHARACTERIZING THE GROWTH REGULATORS

Growth is often defined as irreversible enlargement in size while development is transformation of apparently identical cells into diversified cells and plant organs. Based on these definitions, the current turf growth regulators can be divided into two types. Type I are those that affect both growth and development (Figure 4). Development not only includes the transformations from a seed to a mature plant in an annual species, but also includes most of the stages of the annual life-cycle within a perennial plant as shown in Figure 3.

The chemistry included in this group all suppress turfgrasses for about a six-week period. Within the Type I group, amidochlor, the proposed common name for Limit, is a suppressor while the others are usually labelled inhibitors. The inhibitors usually stop growth immediately after application while the suppressors allow for some growth. This may be partially due to the time it takes for Limit to be absorbed by the roots and partially due to its mechanism of action. Regardless, the end result is a gradual reduction of growth that eventually approaches inhibition. The concept of a suppressor is not to stop growth and mowing, but to permit slow replenishment of turfgrass leaf tissue and utilize trim mowings as needed.

Other chemicals known to inhibit growth and development of cool-season grasses are shown in Figure 5. These are defined as the herbicide types because all have a primary use as a herbicide. The herbicide types are characterized as having a very narrow margin of safety on cool-season grasses and accidental overdoses can quickly and easily kill turf.

However, the sulfonyl ureas and imidazinones will likely find use on roadsides as a grass growth inhibitor with the primary benefit of long term broadleaf weed control. Glyphosates are also effective as grass suppressants with short term broadleaf weed control. Annual broadleaves are often eliminated. In addition, tolerant grasses will survive and compete against more susceptible grasses as evidenced by bermudagrass release from Johnsongrass infestations.

Type II turf growth regulators are those that suppress growth only (Figure 6). The developmental sequence of the plant continues; however, new plant organs develop in miniature size. Examples of this type include paclobutrazol or PP-333 and flurprimidol, also known as EL-500 or Cutless. These compounds are often referred to as the anti-gibberellins and are effective internode elongation suppressors.

Fungicide Type II growth regulators are those that are primarily used as a fungicide but have a use as a growth regulator (Figure 7). The fungicide, fenarimol, was developed as a fungicide and is now being recommended for use on putting greens for selective suppression of annual bluegrass. Additionally, paclobutrazol is derived from isomers, one of which is the growth regulator and the other a fungicide. Applications of paclobutrazol have been documented as controlling *Septoria* species.

LIFE-CYCLE RESPONSES TO THE REGULATORS

If a Type I PGR is applied at Stage I, the most noticeable effect is a delay of spring green-up. Since development is slowed as well as growth, the rate of appearance of new green leaves is slowed and the size of the leaves is diminished. Root active growth regulators are effective in reducing growth when applied at this stage while foliarly active compounds require green leaves to absorb the product.

Application at Stage II results in delay of further green-up and subsequent growth suppression. Application at this stage is desirable since the turf has greened sufficiently and rapid spring growth never gets started.

Stage III is considered the optimum time for application of Type I PGR's to provide good turfgrass quality and the normal 5-6 week duration of vegetative suppression or inhibition. Often there is a slight loss of turf quality from the 2nd to the 4th week from leaf aging and enhanced dark green color from the 7th to the 10th week or longer. Seedhead control is usually greater than 90 percent for applications made during this stage.

Rapid vertical vegetative growth signals the beginning of Stage III. Seedhead elongation signals the end of the stage which is the latest application time for optimum results. As soon as the first seedhead is visible above the boot leaf, the application time is over, especially if a root absorbed product cannot be watered in immediately after application.

Applications of any Type I growth regulator at Stage IV can be detrimental to the appearance of the turfgrass area especially if the grass is a stemmy type. Growth regulators do not reverse the effects of the hormonal signal and, in effect, work cooperatively with the signal to completely inhibit growth of existing leaves. Likewise, they do not reverse the signal for tiller initiation but do greatly slow tiller development, at least for a time. Eventually one or more lateral buds, deep in the thatch and not having sufficient product, receive the signal. When that occurs these buds rapidly grow and develop into tillers.

Thus, application of Type I PGR's at Stage IV results in undesirable turfgrass responses: (1) excessive growth inhibition for a short period, (2) severe loss of turfgrass quality as leaves senesce and die, and (3) early termination of activity due to rapid growth of escaped tillers not affected by the product.

TURF QUALITY ENHANCEMENTS RESULTING FROM PROPER TYPE I USE

The significance of this signal reinforces the fact that Stage III is the preferred time for application. Since developmental inhibitors applied during Stage III prevent seedheads from developing, they also prevent the signal from being sent and prevent the negative turfgrass quality consequences of the signal. Therefore, these PGR applications can actually result in improved turfgrass quality compared to a nontreated area undergoing the "stemmy" reproductive physiology phase. Further, the effect of preserving leaves seems to be accompanied by a preservation of existing roots. As a result, observations of improved summer growth, color, rooting, and tolerance to summer stresses including heat, drought and diseases have been observed when using some Type I growth regulators.

TYPE II REGULATORS

Because Type II plant growth regulators do not suppress plant development, applications at any of the stages from I through IV can result in (1) diminutive seedhead expression below the mowing height, (2) senescence and death of the main tiller, and (3) suppression of the size of the new tillers that normally grow large and mask the dying leaves. Therefore, no stage of application on stemmy varieties in the spring is acceptable for Type II plant growth regulators.

It is important to state that the Type II regulators do show acceptable results on non-stemmy, highly vegetative species and varieties. For instance, tall fescue seedheads apparently can quite easily be mowed off prior to the signal, even when stunted by a Type II regulator and good results have been achieved. Type II growth regulator use on Baron Kentucky bluegrass, however, has not been as successful. Apparently, stunting the seedhead height does not permit the mower to remove the seedhead soon enough to prevent the natural signal and the leaves usually senesce and brown off rapidly during Stage IV. Finally, it should also be noted that Type II growth regulators have shown excellent performance in the fall season when perennial species do not exhibit the reproductive growth stage.

CHOOSING THE PROPER GROWTH REGULATOR FOR PROPER TURF CLASS

Use of all turf growth regulators of Class A turf is extremely limited at this time, and more research is needed to reduce the visible off-color of aging turf and to insure protection from pests that often damage turf areas being managed at a high level. However, where slight off-color in the off-season can be tolerated in exchange for improved color and survival during the outdoor busy season, the materials that result in minimal off-color have been used effectively.

In addition, there are several specialty uses in Class A turf for certain growth regulators. Mefluidide has been used successfully for seedhead control of annual bluegrass in intensively maintained turfs. While in some cases it has been reported that seedhead control has reduced annual bluegrass populations through reduced seed available for germination, others have reported greater annual bluegrass populations due to inadvertent conversion of an annual species into a perennial species by eliminating the reproductive and maturation phase of the plant. For those turf managers who desire to keep annual bluegrass rather than kill it, improved appearance from less seedheads and improved summer survival of this species from proper use of mefluidide in the spring has been valuable.

In addition, the Type II growth regulators have been used successfully to reduce annual bluegrass populations. This has been true for flurprimidol, fenarimol and paclobutrazol. These compounds have been reported to have both selective suppression of mature annual bluegrass in perennial grasses as well as elimination of competition from seedling annual bluegrass that develops in miniature and cannot compete in the existing turf.

The final consideration for use of growth regulators on Class A turf centers on hard-to-mow areas where mechanical mowing may result in more problems than the leaf aging, off-color appearance associated with a growth regulator. For instance, spring rains often delay mowing schedules. When mowing resumes, wet conditions preclude the use of a mower on steep slopes, ditch banks, low spots and areas full of obstacles. If mowed mechanically, soil displacement and/or excessive wear and tear of the turf may occur. Thus, areas of Class A turf that present these special problems can be preselected early in the season and treated with a growth regulator to prevent damage that usually far exceeds off-color from a growth regulator.

Class B turf represents the greatest potential for cost effective use of growth regulators. Many areas of turf are mowed on a frequent basis yet do not receive other management inputs. It is on these areas that growth regulators can blend into mechanical mowing programs and greatly reduce the costs, time consumption and headaches of maintaining these areas. That allows more time to attend to Class A turfs that are most important in projecting the desirable aesthetic image.

Most of the Type I and Type II growth regulators can be used successfully on Class B turf. However, because of overlap safety, uniform grass response and safety to ornamentals in the landscape, Limit is the easiest to apply.

Type I, herbicide Type I and Type II growth regulators can be used successfully on Class C turf. However, the herbicide types can injure or kill cool-season grasses at an unacceptable frequency and should only be used with extreme caution.

In order to reduce the chance of injury, herbicide types have been mixed with other Type I growth regulators with a good degree of success. One key advantage of mixing is to reduce the quantity of residual action of products that have a long half-life in the soil. As an example, the mixture of glyphosate with a sulphonyl urea has certain highly desirable characteristics. Even though glyphosate is a herbicide type, because of its negligible soil residual, combination with a sulfonyl urea product can reduce the amount used and, thus, reduce the potential for movement of chemistry from the site of application resulting in latent injury to the vegetation.

As mentioned earlier, warm-season grasses have shown a greater tolerance for the herbicide type growth regulators. Thus, all growth regulators can be used effectively on warm-season Class C turf except for Limit. Because foliar uptake of Limit is ineffective, microbial degredation of Limit is rapid and warm-season grasses are deep rooted, Limit cannot be effectively absorbed and translocated to the growing point.

The most widely accepted chemicals for Class D vegetation are the herbicide type, especially those with residual action. For the most part, bare ground is considered acceptable, at least for a short period of time. The biggest concern with residual types is associated with mobility of the products to surrounding desirable vegetation. Again, advantages exist in mixing residual with non-residual types because rates of residuals high enough to produce "burn down" have potential to injure and kill surrounding vegetation.

SUMMARY

Identification and characterization of plant growth regulators for turf have been complicated by the variation of biological response of grasses. The annual lifecycle of grasses has been shown to play an active part in the growth response to regulators and may, in fact, play a greater role in the erratic performance of growth regulators than the chemical or the application procedure.

Plant growth regulators have made agronomic impact on Class D and Class C vegetation. Hopefully, with greater knowledge of how turfgrasses grow and develop, greater impact will occur on Class B and Class A turfgrasses.

Figure 1

Vegetation Management Classification

- **Class A**
  Frequent mowing, fertilization, and pest control; Often irrigated
- **Class B**
  Frequent mowing; Occasional weed control and fertilization
- **Class C**
  Infrequent mowing; Occasional weed control
- **Class D**
  No mowing, Occasional brush and weed control

Figure 2

Plant and/or Soil Residual Action

- 1 Month
  amidochlor
- 1-2 Months
  glyphosate
  mefluidide
  maleic hydrazide
  chlorflurenol
- 2+ Months
  paclobutrazol
  flurprimidol
- 3+ Months
  imadazolinones
  sulfonyl ureas

Figure 3

ANNUAL LIFE CYCLE OF PERENNIAL COOL-SEASON TURFGRASSES

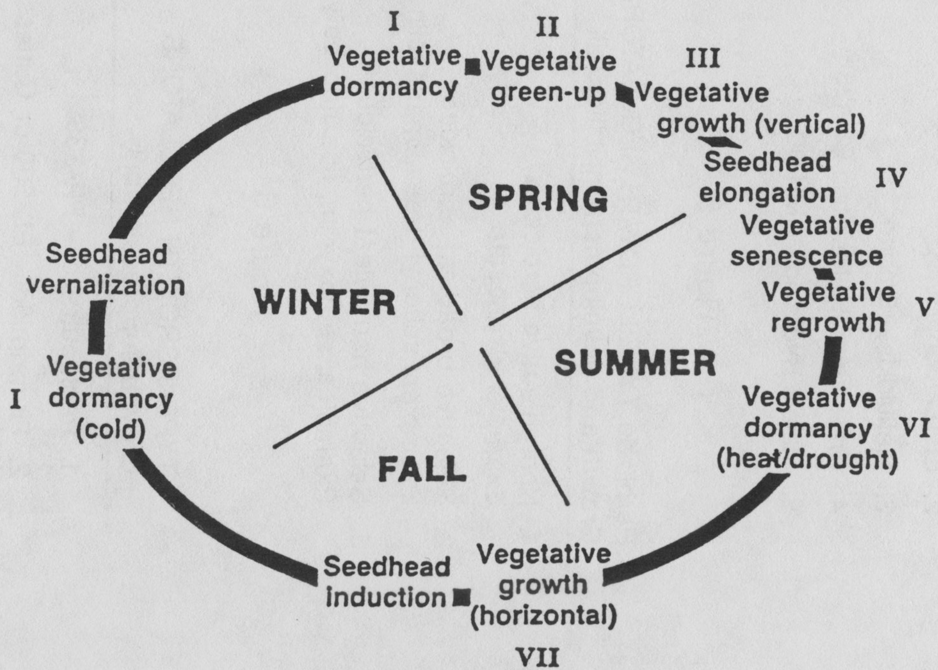

Figure 4

TYPE I GROWTH REGULATORS
Growth and development suppression

1. Amidochlor - Limit
2. EPTC - Shortstop
3. Mefluidide - Embark
4. Chlorflurenol - Maintain CF-125
5. Maleic Hydrazide - MH-30

Figure 5

Herbicide TYPE I GROWTH REGULATORS
Growth and development inhibition/kill

1. Non-selective herbicides
   Example: glyphosate
2. Selective broadleaf herbicides
   Examples: sulfonyl ureas, imadazolinones
3. Selective narrowleaf herbicides
   Examples: sethoxydim, fluazifop-butyl

Figure 6

TYPE II GROWTH REGULATORS
Growth suppression only

1. Paclobutrazol - PP-333
2. Flurprimidol - EL-500 or Cutless

Figure 7

Fungicide TYPE II GROWTH REGULATORS
Growth suppression, disease control

1. Fenarimol - Rubigan

CRITICAL ELEMENTS AFFECTING A DRAINAGE SYSTEM[1]

Carl H. Kuhn[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
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It is always interesting to ask an assembled group such as we have here at the Conference. . . "How many of you DO NOT have some form of drainage problem on your golf course?" Those of you who raise your hands most likely come from the more arid regions of the Northwest or you have the one in a thousand golf courses built on beach sand or desert sand. Let us fact it: traffic, excess moisture and fine grained materials, when combined, create drainage problems. There are other contributing culprits which we will define later on but the BIG THREE . . . TRAFFIC, EXCESS MOISTURE and FINE GRAINED SOILS are the team that changes the SUPER BOWL to the SOUP-ER BOWL somewhere on the hundred plus acres that you care for.

GREENS AND TEES

Let us first address the problems found on sand-constructed greens and tees. Any of you who have re-constructed poor draining greens with a new sand-underdrained structure, U.S.G.A., W.S.U. or some modification thereof, must have assumed that the many thousands of dollars spent provided you with a permanent cure-all. No more drain problems on the new tees and greens. . . RIGHT? WRONG! Like any properly constructed machine, maintenance must follow proper design and construction. Let us take a look at the problems that can be experienced from the outset remembering that on greens and tees we are looking for RAPID movement of water away from the surface even under quite heavy rainfalls. While a tulip farmer can wait three days for his field to lose a newly found lake that resulted from a heavy rainfall, a golf superintendent is expected to magically make water disappear as soon as the golfer comes out from under the protective cover of the nearest gazebo.

Green and Tee Drainage Design

1. Improper selection or gradation of sand. Too fine a sand slows drainage rate. Too coarse a sand makes for good drainage but poor turf growing conditions. Some gradations can compact like concrete.

2. Contamination of sand with fines. The more fines you introduce to a medium grain sand, the more compaction you have and the slower drain rate can be expected. Insist on clean sand with no more than 2% passing the No. 200 sieve.

3. Improper depth of sand. The depth of sand and the spacing of drain tiles go hand in hand. If sand is hard to get, space tiles close; if you find the digging objectionable, space tiles further apart but deepen the sand depth.

4. Improper spacing or grading of drains. See Item 3 above. Drains need 1/2 of 1% to flow properly. This item is a hard one to violate but some do it on paper and some do it in the field.

5. Improper depth of underlying gravel. I do not think I am the first to suggest that you can construct a green or tee WITHOUT a complete gravel bed underlying the sand and organic mixture. We know it works because we have constructed many athletic fields in this manner. Improper depth of gravel might better be considered as too much unneeded gravel.

6. Improper selection of underlying gravel size. If you feel that you need gravel as a blanket rather than as a simple filter zone around the drains, be selective in the size of that gravel. Large diameter gravel, 1/2 inch and larger, creates a perched water table because of the great difference in granule size between medium grain sand and "drain gravel". If you must use a gravel blanket, use pea gravel of 4x8 gravel.

7. Improper selection of drain pipe and geotextiles. There is little doubt that corrugated-perforated polyethylene pipe has become the standard of the industry. You may know it better by some of the various trade names such as ADS or Hancor. We consider this pipe the greatest drainage innovation since Newton discovered gravity. So don't squeeze the dollars. Use a pipe of adequate size to guarantee a permanent and large void where the pipe rests. One can rationalize that a 2 inch drain pipe will never be full when designed into an under-green network, and this is very true. So why spend the dollars to install a 4 inch? Answer: It insures a large diameter draining void more like to withstand silting, roots, etc.

Geotextiles: A great innovation when used in the right place. A disaster when improperly used. It must be remembered that when using a filter-cloth of any sort, the size of the filter-cloth mesh is most critical. If you are intending to use such a cloth to keep your sand or gravel "clean" by screening out silt particles, you will be collecting the silt on the fine mesh cloth. Now that you have successfully screened out the silt, you have also slowed down the rate of movement of water through the cloth. The silt particles have plugged many of the small filter-cloth openings and diminished the flow area thru the cloth. This is absolutely contrary to what we are looking for on a golf green. . . very rapid exodus of water.

We feel very strongly that a fast-draining, permanent green drain system can be constructed without filter-cloth. First of all, a properly constructed green should not have a surplus of silt that would plug a filter-cloth; insist on clean sand to start with. Secondly, a properly selected gravel encasement for the drains will serve as a reasonable filter IF you have any silt at all. This is why we strongly recommend the use of pea-gravel or 4x8 gravel, both relatively small in size, free draining and excellent filters. Lastly, by sizing the drain pipe to 4 inches, you have sufficient void to insure drainage even if you artificially introduce unwanted fines.

8. Improper use of ''Top Soil''. ''Top Soil'' is an undefined mix of sands, silts, organic and a piece of the kitchen sink. Do not use amendments such as ''Top Soil'' in place of organics to give your sand some body. All you have done is to introduce silts which will slow drainage and which will compact and further slow drainage.

FAIRWAY DRAINAGE

This subject is as broad as it is long. Time and space does not permit a complete review of the subject. We can abbreviate by pointing out the causal factors for poor fairway drainage.

1. Excess moisture 2. Excess traffic 3. Fine-grain soils

Isn't this the same thing we said about greens? You are absolutely correct except you must remember that we used an extremely expensive remedy which cannot be applied economically to 70 or so acres of fairway. Where do we go from here? We suggest the following:

1. Determine the source of the excess moisture. Dig test holes to find out if the water source is from underground springs, etc. (Seldom do we find this to be the case, but we have to dig the test holes to find out).

2. If you show no measurable underground water, then you can rest assured that your source of water is plain old rainfall that cannot find its way down and thru the subgrade in a rapid manner. Slow drainage and traffic simply disturbs the soil structure further and creates the ''Soup-er Bowl'', an even more slow draining condition.

3. You may elect to have sieve tests run on the subgrade just to prove what you already know which is that your soil is high in silt, clay, glit or a combination of all three.

Now that you have determined the problem, what is there for a remedy? There are few remedies that are inexpensive. Nature has bestowed you with over a hundred acres of tight soils and the Greens Committee expects you to correct the many drainage problems. Here are a few of the approaches we have used.

A. Selective removal of soils in very high traffic areas and replacement with drainable permeables and tiles. Be certain that you have someplace to dump the water.

B. Sand Topdressing: Found to be useful where there is no other avenue of escape. Three inches of clean, medium grain sand applied over a three year period, augmented by a few intercepting drains will improve the surface measurably. Not an inexpensive remedy by any means.

C. Drains Alone: Can be used where there is sufficient evidence that the subgrade will permit horizontal flow of water. In cases where this method has succeeded, it was found that a permeable layer of material overlaid an impervious clay. DO NOT TRY TO DRAIN VERY HEAVY SILTS OR CLAYS BY DRAIN TILES ALONE. You will generally find that all you have done was to drain the soils for one foot on either side of the drain.

D. Selective Contouring: Can help a course when combined with exit sumps, sump pumps, etc. Remember that water will not run off a grass slope unless the slope is at least 3%, so the slopes cannot be gentle. Also remember, that water will not run off a grass area until the water has first saturated the subgrade. Contouring then only gets rid of the excess water and simply keeps the situation from becoming worse than it already is.

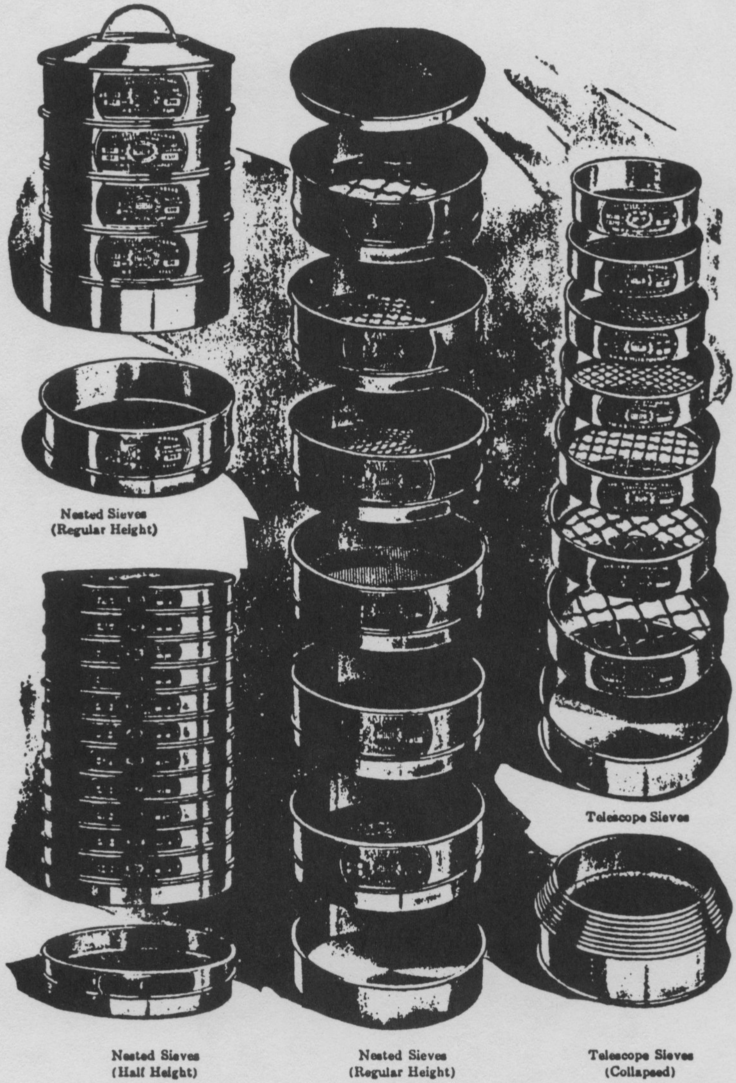
E. Normal Maintenance: Aerifying and verticutting will reduce a thatch layer that can become a major constraint to drainage. We have found cases where 2 inches of dense thatch was sufficient to prevent surface moisture from entering a perfectly permeable sand subgrade.

F. Cut-off Trenches: Where there is evidence of sub-surface water, simple cut-off trenches using corrugated-perforated poly and fine gravel, and exited off the fairway will resolve the problem. Do not look for this remedy as an escape. . . we have found underground water to be the culprit in one out of fifty drainage studies.

SUMMARY

There is little reason for poor drainage in new greens construction since there is so much good documentation on proper construction. We can put that issue to rest by simply suggesting that you live by the check points we have discussed here today.

The fairway problem is a different matter. While the types of soils you find on your golf course may be the most logical culprit affecting poor drainage, each case seems to be somewhat unique and special. For this reason, we cannot provide a blanket cure-all but rather suggest you utilize visual soil identification, perc tests and sieve analysis to help you arrive at the least expensive corrective measure. Even then, the remedy may be too costly. You, like many other turf managers, especially in the Puget Sound and Willamette Valley regions, may find that only the increase in evapotranspiration and the decrease in rainfall brought about by spring weather, will cure your winter drainage blahs. And that is the Gospel Truth!



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TYPICAL AGGREGATE SCREENS

Sand shall meet the following specifications:

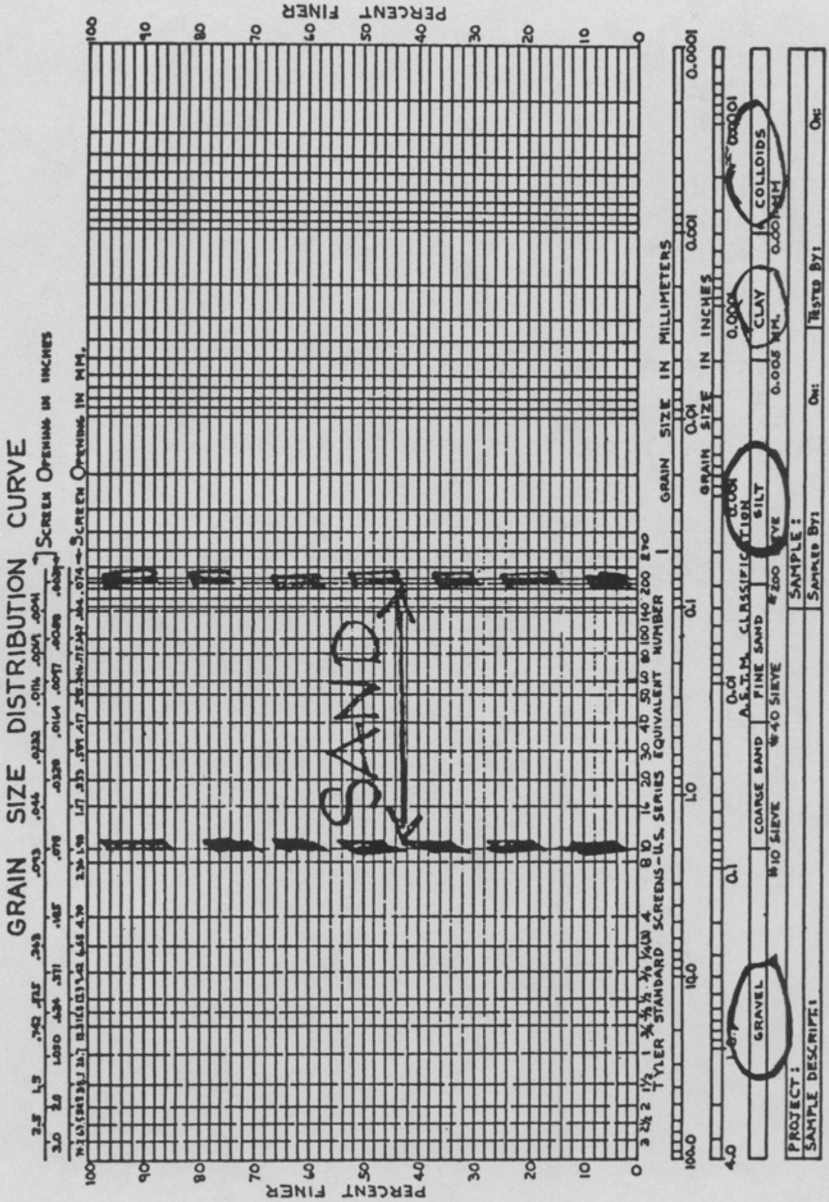
Sieve	Percent Passing
#4	100%
#8	95-100%
#16	85-100%
#30	50-75%
#60	0-30%
#100	0-10%
#140	0-5%
#200 *	0-2%
#270 *	0%

* indicates wet sieve test

Sand shall be fresh water washed.

IDEAL SAND FOR FAST DRAINING TURF SURFACE

WHAT IS SAND??????????


GRAIN SIZE DISTRIBUTION CURVE
SCREEN OPENING IN INCHES
SCREEN OPENING IN MM.
TYLER STANDARD SCREENS-U.S. SERIES EQUIVALENT NUMBER
PERCENT FINER
SAND
GRAIN SIZE IN MILLIMETERS
GRAIN SIZE IN INCHES
A.S.T.M. CLASSIFICATION
GRAVEL
COARSE SAND
FINE SAND
SILT
CLAY
COLLOIDS
#10 SIEVE
#40 SIEVE
#200 SIEVE
0.005 MM.
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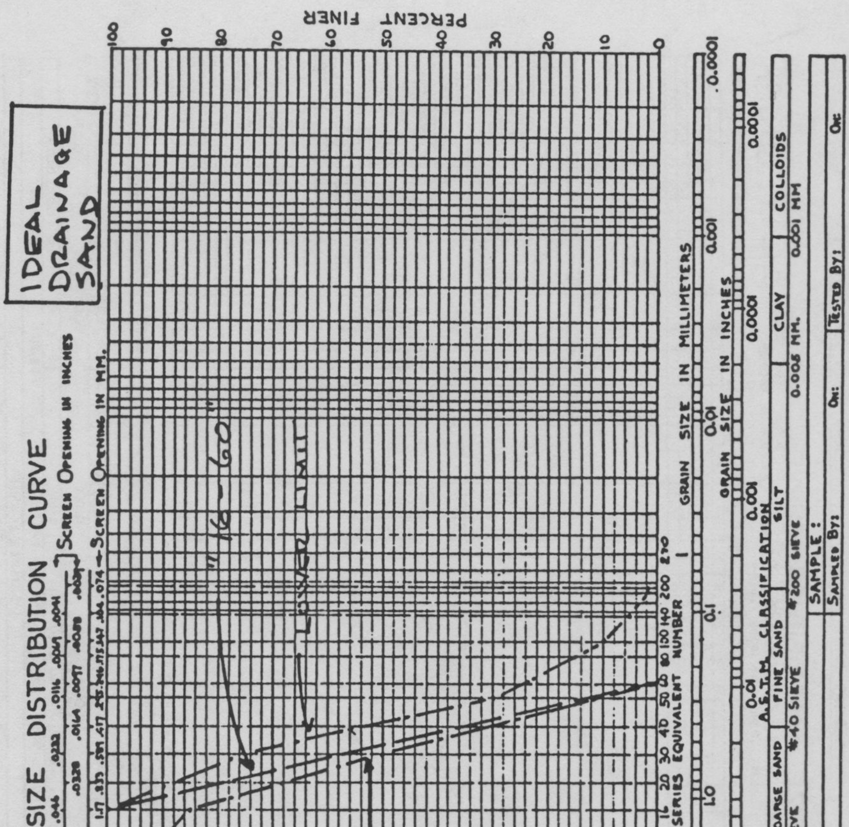
GRAIN SIZE DISTRIBUTION CURVE
SCREEN OPENING IN INCHES
SCREEN OPENING IN MM.
IDEAL DRAINAGE SAND
"16 - 60"
LOWER LIMIT
UPPER LIMIT
PERCENT FINER
TYLER STANDARD SCREENS-U.S. SERIES EQUIVALENT NUMBER
GRAIN SIZE IN MILLIMETERS
GRAIN SIZE IN INCHES
A.S.T.M. CLASSIFICATION
GRAVEL
COARSE SAND
FINE SAND
SILT
CLAY
COLLOIDS
#10 SIEVE
#40 SIEVE
#200 SIEVE
0.005 MM.
0.001 MM
PROJECT:
SAMPLE DESCRIPT.:
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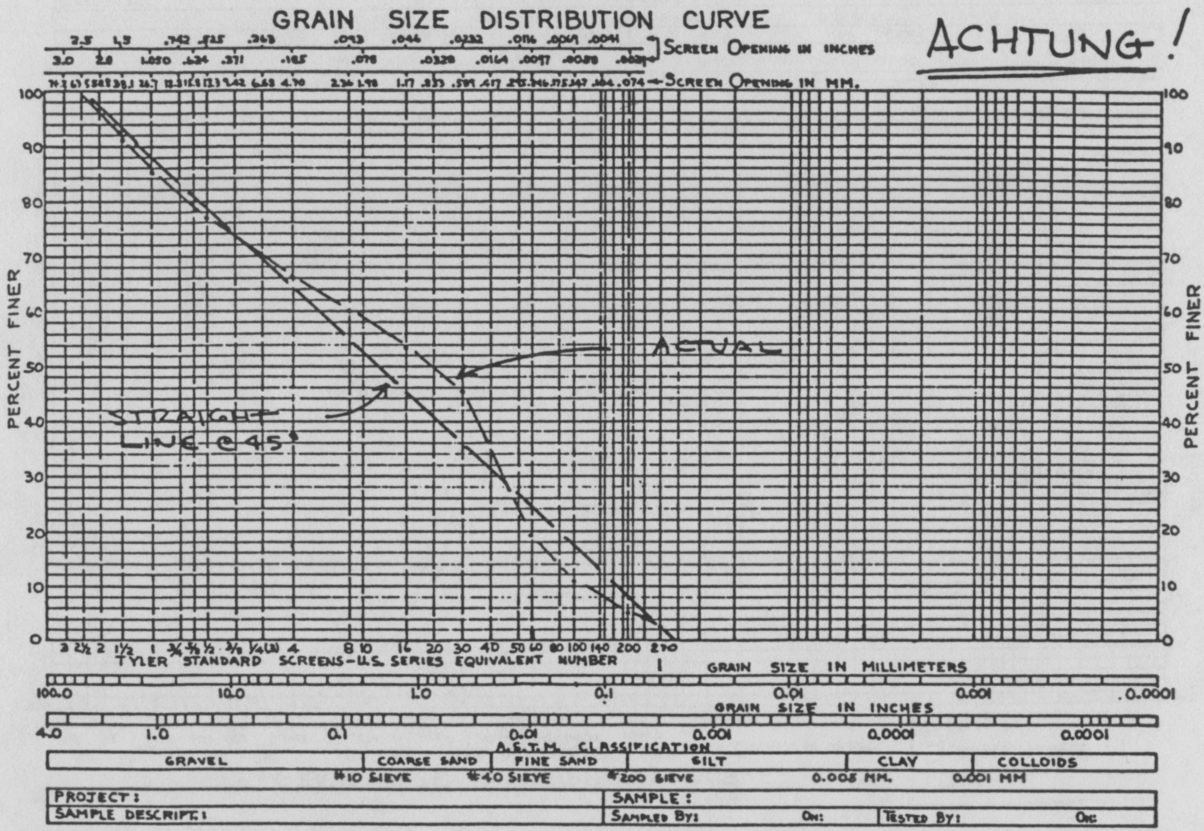
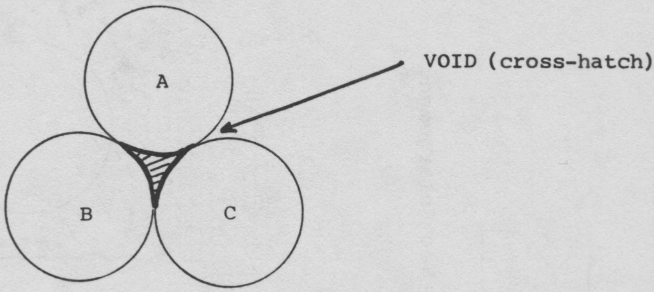
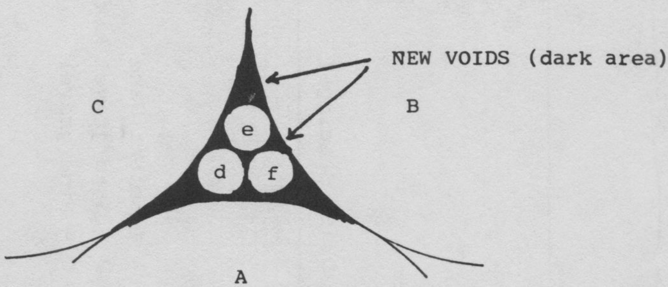
EXCELLENT BASE MATERIAL FOR CART PATH PAVING!!!!



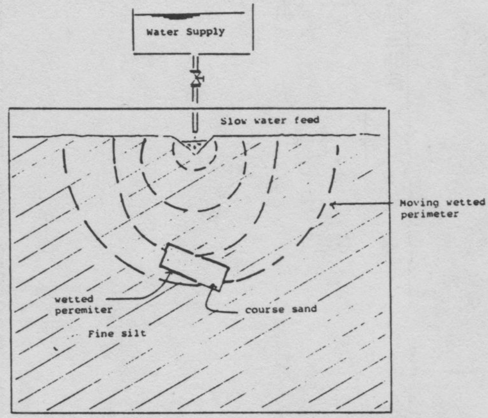


THREE-PARTICLE VOID   No Scale

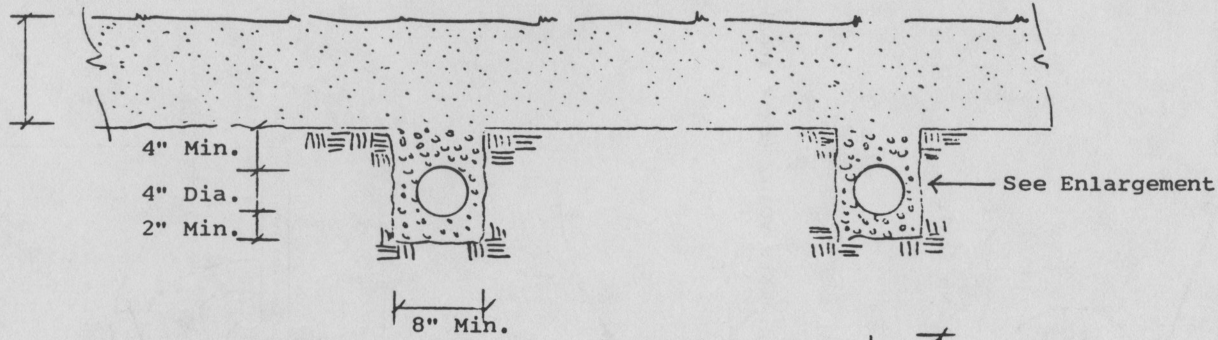


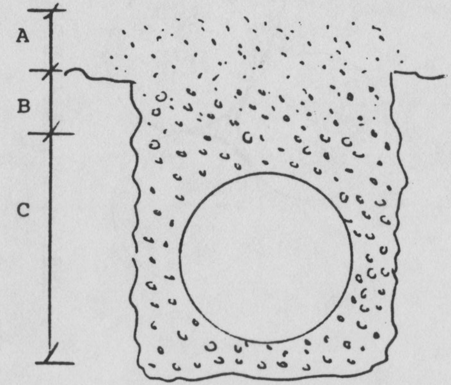
THREE-PARTICLE VOID (ENLARGED)   No Scale

Wetted perimeter passes course sand completely before it starts wetting the course sand.



THE OLDE WAZU TEST





Drain Enlargement

<u>DRAINAGE FOR FAST-DRAINING TURF</u>

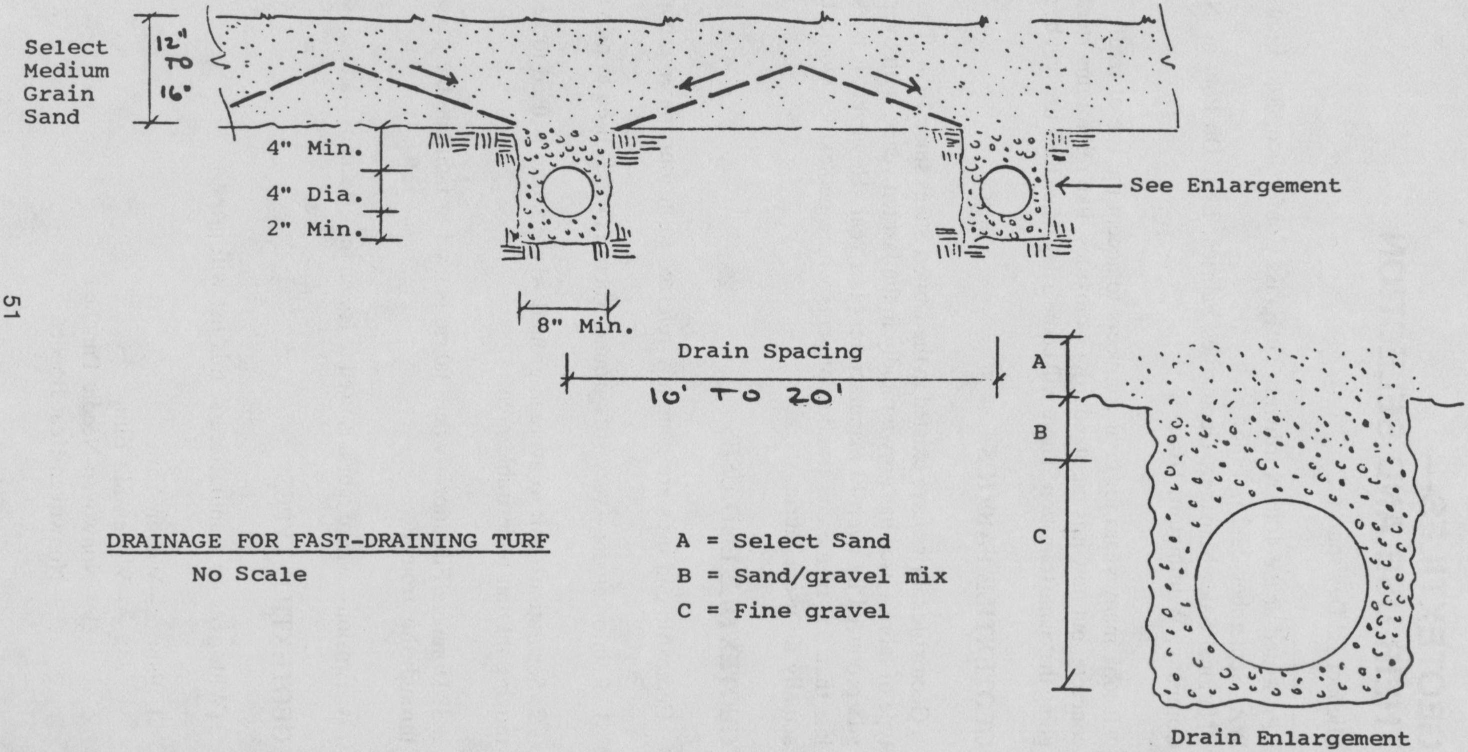
No Scale

A = Select Sand

B = Sand/gravel mix

C = Fine gravel

FLAT SURFACE



DRAINAGE FOR FAST-DRAINING TURF

No Scale

A = Select Sand

B = Sand/gravel mix

C = Fine gravel

GEOTEXTILES— THEIR USE AND SELECTION[1]

Michael E. Dewsbury[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] National Sales Manager, Geotextiles Fabrics, E. I. Du Pont de Nemours and Company, Wilmington, DE.

It took many years for civil engineers to accept the use of reinforcing steel in concrete, but now it is the standard. Geotextiles, like reinforcing steel, are undergoing that same transition. There will come a day when their use will be the standard.

GEOTEXTILE FABRICS

Geotextile fabrics have existed in the United States since 1958. The volume and type of fabrics used has grown rapidly in the last ten years, with over 250 million yd$ produced by over 40 manufacturers last year. However, it is estimated that less than 5% of the construction projects where geotextiles would be beneficial actually do use a fabric.

GEOTEXTILE END USES

Geotextile end uses are generally referred to in four major groupings.

1. Reinforcement—very soft ground where fabric is used to provide strength.

2. Separation—soft to average ground where fabric is used to keep soil from moving into an undesirable area.

3. Drainage/Filtration—where fabric is used to facilitate the passage of water through the ground.

4. Erosion—where fabric is used to lessen the effects of water on soil particles.

GEOTEXTILE TYPES

(With over 40 manufacturers, this list will grow.)

1. Fabrics—Woven-Yarn
   —Woven-Slit Film
   —Nonwoven-Needle Punched
   —Nonwoven-Heat Bonded

2. Composited—Structures made to carry water in their plane. Usually a thick, porous core covered with a geotextile fabric which keeps dirt out of the core drain area.

MAJOR MANUFACTURERS

Amoco
DuPont
Phillips
Mirafi
Hoecshst
Exxon

APPLICATION EXAMPLES

Parking Lots or Pathways (gravelled or paved). Non fabric installations can break down with time because the base becomes contaminated with fine soil from below and will not drain, causing pot holes and frost heaves. Signs of base failure are alligator cracks, pot holes and ruts.

Fabric Installation Helps in These Ways:

1. Separation and Drainage. The original base is designed to carry a load. This occurs as planned as long as the base remains well-compacted since aggregate is strong only in compression. Without a fabric, vehicle passage causes fines to pump up from below. These fines act as a lubricant allowing the aggregate stones to move. The fines also fill voids between the coarser aggregate stones trapping water in the base. This water acts as a lubricant and can freeze in colder climates causing frost heaves.

2. Reinforcement. Even good soil is nonhomogeneous. Soft spots can occur randomly throughout an area. Without a geotextile fabric, these soft spots, when compressed, cause a rutting in the surface. Geotextiles can help span these soft areas by creating compression arches in the aggregate on top.

Considerations with this type of installation are:

1. Fabric must be strong enough to withstand installation abuses.

2. Fabric must have a uniformly high modulous.

3. Fabric must have sufficient permeability.

DRAINAGE TRENCHES

Non-fabric installation can clog with time as unsupported soil spills into the voids between stones.

Installations with fabric hold soil in place like a well screen so only water passes through to the drain.

Drainage constructed without a geotextile fabric should use graded aggregate filters. These can require expansive materials and are always difficult to install. Geotextiles are relatively cheap and are easy to install. Properly chosen and installed, geotextiles will work very well and they do not clog.

Considerations in this end use are: Fabric openings must be large enough to pass the required volumes (more capacity than the soil being drained) and small enough to hold at least 85% of all soil particles in place. (The other 15% is held by the soil itself.)

COMMON FABRIC FAILURES

1. Smearing with fine wet soil during installation can fill fabric voids reducing permeability.

2. Clogging can occur when soil in contact with the fabric is not stable and fine particles wash through to the fabric. If fabric catches the particle, it clogs (much like a filter in a slurry tank). If it doesn't, ground around the drain can erode. Unstable soil can be caused by large voids behind fabric, water turbulence, or gap grading. These situations would also cause failure of a graded aggregate filter.

3. Insufficient overlap can cause two fabric sheets to separate and allow soil to enter.

4. Tearing can be caused by improper installation. Fabrics are not designed to be driven on directly with heavy construction equipment.

SUMMARY

Geotextile fabrics are still in their infancy. Much is yet to be learned about their capabilities and requirements. Manufacturers have created most of the information available today. Some of it is good, some is not. If you have specific fabric needs, contact a reputable manufacturer and ask questions. Most of us are very willing to help.

Fabrics, when used correctly, can improve both the quality and costs of your earth construction projects.

EFFICIENT USE OF FUNGICIDES ON TURFGRASSES[1]

Richard W. Smiley[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

[2] Professor of Plant Pathology, Oregon State University, Columbia Basin Agriculture Research Center, Pendleton, OR.

Today's turfgrass disease control chemicals are the result of sophisticated technological advances. Rather selective fungicides are entering the market to replace less sophisticated biocides. During this process it becomes even more necessary for the turfgrass manager or advisors to accurately diagnose diseases, and to apply disease control strategies that suppress the most predictable and serious diseases at each location. Inefficient uses of modern fungicides is one of the difficulties being experienced in implementing new heights for disease control on turfgrasses.

This discussion will be a brief review of chemical controls for turfgrass diseases. It will include a perspective of the fungicide history, mode of action, spectra of activity, risks of causing phytotoxicity and fungal resistance, application strategies and techniques, and fates in the environment. Some effects of fungicides on processes other than those for which they were applied (e.g., ''nontarget effects'') are also presented.

HISTORY

Bordeaux mixture was the first fungicide to be widely used on turfgrasses. Although its use in the early 1900's was short-lived because of copper toxicity problems, it served to stimulate additional interest in suppressing diseases on turfgrasses. The first significant advance toward effective turfgrass disease control occurred when the inorganic and organic mercury fungicides were developed in the 1920's and 1930's. Another important discovery came in 1931, with the synthesis of dithiocarbamic acid - the precursor of thiram, maneb, nabam, zineb and others. Although the first dithiocarbamic-acid derivative, thiram, was tested on turfgrasses prior to 1941, it was not formulated and made available for general use until after mercury shortages occurred during World War II. Zineb also became available in the late 1940's.

Fungicide development became intense in the 1950's, with the release of cycloheximide, the cadmium fungicides, more mercury fungicides, captan, quintozene and anilazine. Major advances in pesticide formulation procedures and in application equipment were also made during this decade. Introductions during the 1960's included chlorothalonil, maneb and mancozeb. But, the two most notable contributions during this decade were the release of fungicides that are specific in activity against *Pythium*-like fungi or are rapidly translocated systemically in the plant vascular system. Chloroneb, etridiazole (=ethazole) and diazoben were released for controlling diseases caused by pythiaceous fungi. Thiabendazole was the first of the translocated fungicides, and it was largely replaced in the 1970's by the more efficient benzimidazole-derivatives; benomyl and ethyl- and methyl-thiophanates. Other systemics released in the 1970's included iprodione, metalaxyl and triadimefon. The last decade was also noted in many regions as the time during which the heavy metal (e.g., mercury- and cadmium-based) fungicides became banned from general use because of actual or potential hazards to worker's health and the environment. In the 1980's we have witnessed a continuation of new fungicides being released, and all are systemically translocated. Phosethyl Al, fenarimol, oxycarboxin, prochloraz, propamocarb, propiconazol and vinclozolin have become registered or are in advanced stages of development.

MODES OF ACTION

Fungicides influence the growth of fungi in many ways. The modes of action for most fungicides fall into three distinct groups: 1) inhibitors of respiration or other energy-production processes; 2) inhibitors of the synthesis of vital biological compounds or structures; and 3) indirect mechanisms that increase host resistance.

Nearly all fungicides in Group 1 are toxic to a broad range of fungi, are no absorbed into plant tissue, and are classed as broad-spectrum SURFACE (or CONTACT) PROTECTANTS (Table 1). Two exceptions are known; respiration inhibitors that are absorbed by plant tissue and translocated include fenaminosulf and oxycarboxin (Table 1). Both chemicals are toxic to only a narrow spectra of fungi.

Group 3 only includes phosethyl A1 (Table 2). Although not directly toxic to fungi, this compound inhibits disease by increasing the host's resistance to attack by pathogens. In the truest sense, Group 3 compounds must be classified as plant growth regulants rather than fungicides.

All other chemicals listed in the tables are representatives of Group 2. Most have the potential for being absorbed into the plant and to kill the fungi that have already invaded plants and initiated the disease process. The latter type of activity is called CURATIVE action or, more properly, CHEMOTHERAPEUTIC activity. Fungicides may move either short distances into the plant tissue, deemed LOCALLY SYSTEMIC, or along the elongate axis to points some distance from the absorption site, called SYSTEMICALLY TRANSLOCATED. The locally systemic fungicides act similarly to the surface protectants and are, therefore, called "narrow-spectrum protectants" in Table 1 and in this discussion. The relatively mobile systemics are retained in Table 2. Some Group 2 systemics affect sensitive fungi by killing the fungal hypha, and others simply stop its growth. In the latter case, whenever the chemical concentration decreases below a subcritical level, the once-inhibited fungus hypha may resume growth. Chemicals that kill the fungus are correctly named FUNGICIDES and those that arrest fungal growth without killing are named FUNGISTATS. Each can be called a FUNGITOXICANT. Because these differences are difficult to classify with precision, all disease control chemicals are loosely named fungicides in this paper. The Group 2 inhibitors of biosynthesis include chemicals that act against proteins (cycloheximide), nucleic acids (metalaxyl), sterols (fenarimol, prochloraz, propiconazol, and triadimefon), and nucleus functions (benomyl, chloroneb, iprodione, quintozene, thiophanate, and vinclozolin).

TRANSLOCATION

In current usage, the word "systemic" is a short form of the more correct term "systemically translocated", and is used in this paper to exclude locally systemic compounds (Table 1). The systemic fungicides (Table 2) may be absorbed into leaves or roots and then moved in the vascular system. Some move very rapidly and over large distances, and others move slowly and over short distances. Most systemics move in an ACROPETAL direction (toward the leaf tip from absorption sites lower on the leaf or in the roots) in the xylem. They are, therefore, carried in the water stream from absorption point. Several systemics also move to a limited extent in a BASIPETAL direction (from foliage toward the crown and roots) in the phloem. Since the phloem is a living tissue (in contrast, xylem tissue lacks cytoplasm and nuclei), the basipetal-directed fungicides are very likely to also affect plant metabolism and/or morphology, especially at high rates of application. In many references the word symplast is used to depict the living cytoplasm in plant cells, and apoplast is used for the non-living or structural components. Apoplastic movement is in the acropetal direction in the xylem, and symplastic movement is often in the basipetal direction in the phloem. None of the current fungicides move only in a basipetal direction, and those that move both ways move much more in the acropetal than in the basipetal direction. Translocation of over 50 percent of the chemical acropetally and less than 0.5 or 1 percent basipetally are rough characterizations known for several of the newest systemic fungicides. The known or suspected characteristics of translocation for systemic fungicides are listed in Table 2.

PHYTOTOXICITY

The amount and type of phytotoxic potential exhibited by fungicides differs in response to the chemical molecular structure, formulation, application procedure, the weather and the turfgrass species.

The composition of the fungicide active ingredient determines whether or not the chemical comes into contact with the plant cytoplasm. The danger increases as the fungicides attain closer contact with living plant cells. The potential damage from fungicides becomes greater in the general sequence from broad-spectrum surface protectants to narrow-spectrum, locally systemic protectants, then narrow-spectrum translocated systemics and finally, broad-spectrum systemics.

The broad-spectrum surface protectants (Table 1) become adsorbed onto host surfaces and not absorbed into the plant; they, therefore, do not normally contact the host cytoplasm or affect plant metabolism. These fungicides are often used at very high rates and frequencies of application. The locally systemic fungicides, listed as narrow-spectrum protectants, are safely applied to turfgrass, but phytotoxicity can result from excessive applications (rates or frequencies). The local systemics may provide limited eradicative (curative) action against some fungal invaders, but like the surface protectants, they do not generally provide prolonged protection against diseases.

Systemic fungicides (Table 2) possess the ability to act as protectants against infection of plants by fungi and also the ability to kill fungi that have already invaded plants and initiated the disease process. Unfortunately, this chemotherapeutic characteristic also means that those fungicides become intimately associated with the cytoplasm of host cells. Since the molecular structure and activity of some systemics are similar to some natural plant products, the fungicides often affect growth and metabolism of plants as well as fungi. The biggest challenge to those who develop systemic fungicides is to discover molecules that are sufficiently toxic to fungi at sub-phytotox concentrations in plants. In practice, recommended rates of application for some of these chemicals also confer sub-clinical effects on plants. At rates and frequencies of application slightly higher than recommended, the phytotoxic effects may adversely affect plant health. Gross abuses of these chemicals are likely to kill plants, and leave long-lasting toxic residues in soil.

Formulations of fungicides differ greatly in their potential for causing toxicity. In many instances it is the carrier into which the active ingredient is suspended or dissolved that causes the toxicity. Wettable powders and flowables are formulated by adsorbing an active ingredient onto a carrier such as a clay mineral, and this is then suspended in water. Almost no phytotoxicity may result from clay carriers and the adjuvants used in association with them. If the fungicidal active ingredient is dissolved in an organic solvent and then marketed as an emulsifiable concentrate, the solvent can erode the leaf cuticle and burn the leaf cells, especially if applied at high concentrations or during hot, bright days. Granular formulations are generally safe.

Highly water-soluble fungicides are often sold in aqueous solutions, and they tend to have moderate to high potential for phytotoxicity, especially if applied at high pressure from a boom sprayer. Problems presumably arise when some of the active ingredient is injected into the plant tissue, possibly through open stomata, and the fungicide then adversely affects cellular functions.

Some turfgrass species or genera are more sensitive than others to certain fungicides. This was quite well known among the mercury fungicides, and less well known for quintozene. New examples are emerging; fenarimol is, for instance, a fungicide that is also useful at higher rates for suppressing growth of *Poa annua* in turfs of *Poa pratensis* or *Agrostis* spp.

SPECTRA OF ACTIVITY

The broad-spectrum surface protectants are toxic to many fungi, but because of physical limitations, are effective only for controlling foliage-infecting pathogens. Most of the surface protectants are very insoluble in water. The molecules are, therefore, suspended in water, but are not effective in penetrating through thatch or soil to become well enough distributed for effectiveness against pathogens which attack below the soil surface. Exceptions occur for several heavy-metal fungicides, which are soluble and may be transmitted into soil in a dissolved state. Thiram and captan are also used as seed treatments to suppress damping-off of seed and of seedlings. As a group, the surface protectants are well known for controlling foliar diseases such as leaf spots and blights, dollar spot, brown patch, rusts and red thread. Since specific matchings of fungicides and affected diseases differ from region to region, personal experience, the pesticide label, and local specialists should each be used in a final selection process.

Broad-spectrum systemics include chemicals effective against dollar spot, brown patch, smuts, rusts, powdery mildew, anthracnose, snow molds, Fusarium patch, southern blight, and possibly take-all (Ophiobolus) patch. Several of the chemicals (iprodione, vinclozolin) are also effective against leaf spot and blight diseases. In several instances the spectra of activity is almost totally dependent upon the precise procedures used in applying the chemicals. For instance, diseases caused by root-infecting fungi are controlled by benomyl only if the fungicide is initially placed in the root zone rather than on the foliage or thatch. For some fungicides that are translocated basipetally as well as acropetally, the method of application is less critical than for those translocated only acropetally.

Several types of narrow-spectrum fungicides are available. Cycloheximide is mainly active against foliar diseases, whereas benodanil, furmecyclox and oxycarboxin are mainly active against basidiomycete fungi that live in soil or thatch, such as *Rhizoctonia*, *Sclerotium*, *Typhula* and the fairy ring fungi. Oxycarboxin has a moderate level of solubility in water and, thereby, provides hope for controlling the deeply penetrating fairy ring fungi. But the best known narrow-spectrum fungicides are those that are used to suppress *Pythium* diseases, including chloroneb, etridiazole, fenaminosulf, metalaxyl, phosethyl A1 and propamocarb.

FUNGAL RESISTANCE TO FUNGICIDES

The population of each pathogenic species in any turfgrass is composed of tens of thousands or even millions of individual spores or mycelium units. These units, called propagules, of the fungus could each be capable of infecting susceptible plants if environmental conditions favor infection and disease. Propagules of different pathogens may be sensitive to the presence of a specific fungicide, or may have one or two types of resistance.

When an entire population of a pathogenic species is insensitive to a fungicide the population is considered to have a natural resistance. *Pythium* species, for example, have a natural resistance to benzimidazole and dicarboximide fungicides such as benomyl and iprodione, while *Rhizoctonia* has a natural resistance to metalaxyl and propamocarb.

In a pathogen population that is normally sensitive to a fungicide, propagules (or forms or strains) may arise, or already exist without having ever been contacted, that are less sensitive to the fungicide. The decrease in sensitivity may be caused by genetic or nongenetic changes in the fungal cell. Repeated selection pressure from the fungicide may enable the less-sensitive strain to become dominant over the sensitive original type, and result in the failure of the fungicide. If fungicide use is discontinued at the location where resistance developed, the insensitive population may retain its dominance (if the change was genetic in origin, and the strain is fit for survival and competition) or quickly shift back to a mostly sensitive population (if nongenetic change caused the resistance, or if the genetic mutants were unfit for survival). A shift in dominance toward the resistant strains can, therefore, temporarily or permanently influence the ability of the turfgrass manager to control diseases with the fungicide relied upon in the past.

Fungicides vary in their potential for selecting or causing insensitive strains to gain dominance. There is generally little or no problem associated with fungicides that lack persistence and affect many biochemical or structural sites in the fungal cell. The surface protectant fungicides are of this type. The high-risk fungicides are those systemics that inhibit one or few processes at a single site in the fungal cell, and are persistent. These characteristics make the fungicides highly effective, but also ensure a high degree of selection for resistance by maximizing exposure of the fungicide to the pathogen. Once a resistance has become established for a specific fungicide, other fungicides that inhibit that identical site in the fungal cell will also become ineffective. This characteristic is called cross tolerance. A fungus resistant to benomyl will, therefore, also be resistant to thiophanates. Other groups of compounds with similar sites of action include (1) iprodione and vinclozolin, and (2) fenarimol, triadimefon, propiconazol and prochloraz.

Experience has shown that some types of systemics encounter resistance problems more readily than others. These risk categories are heavily dependent upon the type of disease and the strategy for using the fungicide. In general, however, the risks of failure are as follows:

High Risk: benomyl, thiophanate, metalaxyl

Moderate Risk: oxycarboxin, iprodione, vinclozolin

Low Risk: fenarimol, triadimefon, prochloraz, propiconazol

The failure of a fungicide to control a disease will only occur when the resistant types become dominant among the pathogen population. Many factors are involved in the rate and extent to which the shift of dominance from sensitive to insensitive strains occurs. Some considerations include the sporulation and spreading rate of the pathogen, the survivability of the insensitive strain, the threshold of infection numbers necessary for disease to become initiated, the nuclear status of the pathogen, and the severity of the disease potential. An exacting branch of science deals in depth with this facet of disease control technology. For the purposes of this paper, it appears important to only mention these factors, without further elaboration. In short, the potential for resistance is likely to differ for each fungus species and in every different turfgrass management regime. Fungicide application strategies to minimize the potential for developing resistance are discussed later.

APPLICATION STRATEGIES

SURFACE PROTECTANTS. Pathogenic fungi that are to be killed by protectant fungicides must, at the time of treatment, be in a physiologically active state (e.g., not surviving as a dormant propagule) and in a readily accessible location. These fungicides are only effective against fungal spores or hyphae on the leaf surface or in the upper thatch. They are not effective for controlling infections of plant roots and crowns, and for halting the activity of foliar pathogens which have already penetrated the leaf surface.

If a surface protectant fungicide is applied after a fungus has penetrated the leaf surface, the disease will continue to develop at that infection site in the leaf. The chemical is not at fault for failing to arrest a disease resulting from infections made prior to the chemical application. The erroneous application strategy may still be of value, however, because the extent of each leaf lesion is often quite restricted, as with some leaf spots. The fungus re-emerges from the infected tissue to produce a new crop of spores and if a spray has been applied, it is likely that the new spores will be killed when they land upon a treated leaf. The disease epidemic progress will then be reduced or halted.

Many droplets of spray may land on the surface of soil or thatch rather than on the foliage. Residues on thatch and on leaf clippings can each reduce the numbers of spores produced by fungi that are involved in thatch decomposition. Unfortunately, many of the fungi that cause disease are also highly beneficial decomposers of organic litter. At certain times of the year it may be desirable to suppress sporulation of fungi that are likely to cause unacceptable levels of disease but, in general, excessive applications of fungicides are contrary to thatch and turfgrass management objectives.

Surface protectants must be uniformly distributed over the leaf to be effective. The volume of water used per unit area is usually high because complete leaf coverage is essential. Wetting agents are either included in the formulations or recommended as additions to the spray tank. They serve to reduce the water surface tension, and thereby prevent its beading on waxy or hairy leaf surfaces, and its rolling off the leaf. Small areas of unprotected leaf allow "gaps" for fungi to penetrate the leaf. It is essential to remember that turfgrass leaves are produced at or near the soil surface and are pushed upward or laterally. The untreated new tissue is always deeply situated in the turfgrass canopy, in a microenvironment that is very favorable for infections, and in a position protected for the least amount of time. The surface protectants must be applied at rather frequent intervals, depending upon the growth rate of the leaf, the presence of fungal inoculum, and the occurrence of weather conditions needed for a particular pathogen to infect the foliage. Assuming the latter two conditions being present, sprays must be applied every 4 to 14 days in the growing season, or as infrequently as every 21 days during periods of low growth. If growth is nil or extremely slow, the chemical decomposition or erosion from the surface becomes more important than emergence of unprotected tissue.

Reasonable control of foliar diseases can be achieved with surface protectants even when application procedures are far from efficient. Since most of these chemicals are low in phytotoxicity, no immediately observable problems occur even when large overdoses or extreme variations in application rates are made. Such irregularities are common with flooding applications and those from non-agitated or hand-held sprayers.

Most surface protectants are formulated in the wettable powder form because the active ingredients are mostly insoluble in water. Water in the sprayer, therefore, only serves as a carrier to allow uniform spread of the fungicide onto the leaf. Granular formulations of some surface protectants are available, but are rather inefficient because it is difficult to get them to spread uniformly on the leaf. They are generally applied at very high active ingredient rates, when dew is on the foliage. The dew serves as a spreading agent. The greatest attribute of surface protectants in a granular form is to suppress sporulation of pathogens growing in the thatch.

It is unwise to apply surface protectants just prior to mowing, or when they will not become thoroughly dried onto the leaf before irrigation, rainfall, or heavy evening dew. Once the fungicides have dried, they are not easily removed from the leaf surface.

SYSTEMICS. Characteristics of the systemic fungicides make it necessary to significantly alter the method of application from those that were accepted when only surface protectants were available. Factors responsible for mandating the changes include fungicide direction of translocation and its potential for causing phytotoxicity and an increase in resistant pathogen strains. These considerations are discussed to illustrate why it is usually inefficient and costly to use the systemics in a manner developed for the contract protectants.

UNIFORMITY OF APPLICATION. Massive overdoses, at least in patches, are always undesirable, but can be allowed when surface protectants are applied. This is not true when using the systemics. For some systemics, the margin of safety between an effective disease control rate and that which is likely to cause phytotoxicity is as low as four times that recommended. It is impossible to prevent overlaps within this magnitude when using hand-held or non-agitated equipment, or flooding applications. Even boom sprayers often create narrow bands of double the intended rate in the zones of overlapping passes across the turf sward. Improper nozzle selection, boom height, rate of travel, or calibration can each cause great variation in dosage rates within each pass. Accurate applications are required when systemic fungicides are being used. This concept is not really new, it is the same as for applying systemic herbicides to control weeds without affecting desirable grasses or shrubbery.

METHODS OF APPLICATION. Systemically translocated fungicides may be used as foliar sprays or as soil drenches, depending upon the specific chemical being applied, the specific disease to be controlled, and the availability of water for performing a drenching application.

Several fungicides, diseases and application scenarios must be considered to illustrate the best efficiency for using systemics. Initially it is important to know in which direction a systemic fungicide is able to move. All of those currently marketed move acropetally (toward leaf tips) and a few also move basipetally (toward roots). But none of the currently known systemics move only basipetally.

Scenario Number 1. Suppose that *Pythium graminicola* and *Pythium vanterpooli* cause root tip necrosis in cool, wet weather and the former also causes foliar blight during hot, wet weather. Suppose also that metalaxyl and propamocarb are each available and registered for controlling the *Pythium* diseases. Both fungicides are translocated acropetally but only metalaxyl also moves basipetally. It is, therefore, clear that propamocarb will be effective against the root rot phase of disease only if the chemical is drenched into the root zone, where it can be absorbed and distributed throughout the plant. If it is applied as a foliar spray, it will only protect the foliage. Fortunately, propamocarb is highly soluble in water and, thus, is easily washed into root zones. In contrast, both the foliar and root disease phases could be expected to be controlled by either foliar spray or drenching applications of metalaxyl, even though the fungicide moves much more rapidly in the acropetal direction than the basipetal direction. Each of these chemicals are unlikely to decrease in efficiency if rainfall or irrigation occurs soon after application.

Applications of these chemicals should be made before root dysfunction proceeds sufficiently to impede flow in the xylem and phloem. If the vascular system is disrupted, the chemicals are also unable to move through the plant to provide curative action. Since foliar symptoms often become apparent only after roots have become greatly affected by disease, it is imperative to predict the occurrence of root diseases, or to at least recognize the earliest visual symptoms. Applications of chemicals made after roots cease to function have no possibility for saving the most heavily damaged plants, but can help the less-affected plants to recover. Labels on product packages usually provide clear guidelines for the optimum times to apply each chemical. Some fungicides have better or more rapid curative activity than others, and this characteristic must be considered in the development of disease control strategies.

Scenario Number 2. Suppose that the foliar-infecting pathogen causing dollar spot and the root- or rhizome-infecting pathogen causing stripe smut both occur on a *Poa pratensis* golf tee. Suppose also that benomyl and triadimefon are each available and registered for controlling each disease. Both fungicides are translocated acropetally but only triadimefon also moves basipetally. Foliar sprays of each fungicide may be expected to control dollar spot, and the spray of triadimefon will also suppress the smut. But smut can be controlled by benomyl only if the chemical is accurately drenched into the root zone. This scenario illustrates that proper selection and application of fungicides can result in combined disease control programs with no additional expenditure of effort.

Scenario Number 3. Suppose that dollar spot must be controlled on an irrigated fairway. The chemicals available for use include benomyl and triadimefon, as in Scenario No. 2, each applied at 1 oz product/1000 ft^2. Your purchase price for a pound of triadimefon was about 2.2 times higher than for benomyl (example only, not precise). Experience has shown that a single foliar application of triadimefon controls dollar spot for 6 to 10 weeks, regardless of the application method. You also know that an equivalent rate of benomyl, when drenched in, will provide 4 to 6 weeks of control. If, however, benomyl is sprayed on the foliage, only 3 to 4 weeks, or less, control can be expected. With these figures in mind, and an anticipated "dollar spot season" of 15 weeks, drenches of benomyl will consume about 1.5 times more chemical than for triadimefon. The overall product cost for benomyl will be about 75% that of triadimefon. If the 25% margin in product cost is less than the added labor, water and equipment required for one additional application during the season, then benomyl would be the preferred choice on the irrigated fairway, where drenching is possible. If product costs are less important than application costs, triadimefon would become the least costly choice. If drenching is not used, then four applications of benomyl would be required, for a product cost equal to that required by two applications of triadimefon, but with twice the labor and equipment costs. The final choice will invariably differ from one situation to another, and include such intangible factors as convenience, "peace of mind", and product sales rebates or "packages".

Additional discussion of the foliar versus drenching applications of benomyl (or the related thiophanates) is warranted. When benomyl is used as a foliar spray to control a foliage-infecting pathogen, its duration of acceptable control is generally only slightly longer than that of a surface protectant fungicide. Benomyl only moves acropetally and, therefore, the newly produced leaf tissue remains unprotected. The treated tissue continues to be mown off the top of the leaf. The curative effect and long residual life of benomyl are all that separates its efficiency from that of the surface protectants. It is also true, however, that the curative effect enables a manager to wait until the disease just begins to occur before applying the systemic fungicide, whereas the surface protectants must be applied preventatively. Applications of benomyl can provide as much as two times longer control when the chemical is drenched into the root zone rather than being left on the foliage.

The process whereby a drenching application provides a much extended period of activity also requires further discussion. Benomyl is not in itself the molecular structure necessary for controlling turfgrass diseases. The fungicide must first be converted by chemical hydrolysis to the fungitoxic chemical methyl benzimidazole carbamate (MBC). The fungicide is sold in the less toxic benomyl molecular form because it is in this form that the chemical penetrates the foliage and roots most efficiently. When benomyl molecules are absorbed by roots, some of the chemical is stored in the root tissue and released gradually as MBC. This provides a slow release of the fungitoxic factor, and long-term protection of the plant. If hydrolysis occurs outside the root, MBC is rapidly absorbed and quickly passes through the plant. It is, therefore, preferred to place the parent fungicide directly into a position where it may be absorbed directly by roots. It should also be noted that hydrolysis of benomyl and the thiophanates may occur in any humid environment - in an opened bag, on standing in a spray tank, in the soil, or in the plant. If an old opened bag is used, or a suspension is stored in the sprayer, one can expect low efficiency to result from their use.

Finally, systemically translocated fungicides are very well suited for application in granular form. The efficiency of granular formulations is much higher for systemics than for surface protectants. This opens the possibilities for uniform applications to be made by small businessmen, homeowners and others who do not have access to boom sprayers, or who must treat areas that are small, irregular, or impeded by obstacles. The granules can be applied with a cyclone spreader or with a drop-type spreader.

Drenching Applications. Efficient utilization of fungicides having only acropetal translocation can be achieved only through precise drenching applications. An understanding of the complexities involved in properly applying these fungicides to the root zone is perhaps the most important concept needed for their efficient use on a day to day basis. Consideration must be given to the weather, the availability of sufficient water at the proper time, the amount of thatch, and the texture and compaction of the soil.

When fungicides dry onto any surface they become strongly adsorbed and are unlikely to be moved by any subsequent applications of water. Adsorption is especially strong on organic matter and clay minerals. If the fungicide is allowed to dry even briefly on the leaf blade, in thatch, or at the soil surface, a large amount of efficiency will be permanently lost. Delayed watering cannot reverse the adsorption, unless the chemical is quite soluble in water. Special precautions must be taken to move insoluble fungicides into the root zone on hot, dry days when the chemical can dry onto the leaf blades or thatch within several minutes. If a powdery residue remains on the foliage when the leaves dry after drenching, much of the efficiency will be lost. It is helpful to wet the grass thoroughly before starting the application and again during the job if drying is likely to occur before applications are completed. Drenching should be thorough or not conducted at all. The amount of water needed for efficient drenches varies with the solubility of the fungicides (Tables 1 and 2). About 2 cm of water, or more, are needed for chemicals with less than 1 g/l solubilities, and much less is needed for reasonably soluble fungicides such as propamocarb and phosethyl A1. If sufficient water is used for drenching procedure, the chemical may be moved off the foliage but not deeply enough into the soil to be accessible to roots. A great loss of efficiency will result.

Practical difficulties complicate drenching procedures. On irrigated areas we commonly operate sprayers right through the sprinklers when drying is likely to be rapid. It is also helpful to apply fungicides very early in the morning while dew is on the leaf blades. This procedure allows for more time to pass between the conclusion of the application and initiation of the drenching procedure. On large nonirrigated areas, drenching is only possible immediately preceding or during a steady rainfall. Personal experience indicates that very good efficiency can be achieved on mature turf on a sandy loam when systemic fungicides are applied with a boom sprayer during a 5 cm rainfall. But care must be taken to avoid excessive rainfall rates or volumes that cause surface runoff; surface water will redistribute the chemical and may remove it from the intended treatment area. Likewise, it is very unlikely that proper drenching can be achieved through flooding type irrigations. The proportion of water moving laterally rather than vertically into the sward is high during flooding, and a highly variable distribution of the chemical is to be expected.

Physical impedence to fungicide penetration into soil can result from excessive thatch depths and soil compaction. Mechanical removal of some thatch and opening slits or cores into the soil can improve penetration of the fungicide into soil. When water flows through tiny pores in soil the flow rate is slow and the thickness of water films is small. These characteristics cause the suspended (not dissolved) fungicide to be rapidly sieved out of the water column. This may occur within a few millimeters depth in compacted or fine-textured soils. If large cracks or pores are present in dry soils, most of the water will flow through the largest channels and cause a nonuniform distribution of fungicide to occur. Cracks in some dry soils can be minimized by watering the soil several days before the chemical application is to be made; this allows swelling clay minerals to close up the cracks.

Programs to Avoid Resistance. Several precautions can be used to reduce the risk that a pathogen population will become resistant to a fungicide. The basic premise to these considerations is that turfgrass managers must minimize the exposure of the pathogen population to a particular fungicide, while maintaining an acceptable level of disease control. Application strategies to achieve this goal are sometimes the reverse of some described previously. It is, therefore, desirable to adjust the strategy somewhat when using fungicides having high risk of causing resistance.

Do not unnecessarily use fungicides against diseases that are not damaging, or against damaging diseases that build up slowly. In the latter case, such as with dollar spot, there is usually plenty of time to arrest disease development after the first symptoms have been observed. Preventative applications increase the risk of resistance.

If possible, choose fungicides that have the least risk for developing resistance, and do not exceed the minimal application rates and frequencies necessary for adequate disease control. Utilize the high risk fungicides infrequently, at times when disease incidence is like to require them the most.

Although drenching applications of systemic fungicides provide much longer control for a given amount of chemical, this practice also allows a continuous uptake of the fungicide and, thereby, favors uninterrupted selection pressure for resistant pathogens. Use of high risk fungicides should be saved for the most important needs, and alternative, lower-risk, fungicides used where possible.

Mixing fungicides is effective for decreasing the rate of emergence of resistance. Such mixing programs can involve alternating the use of several fungicides through the disease season, or of mixing two or more fungicides in the tank and spraying them simultaneously. Much discussion has dealt with the advantages and disadvantages of each approach. Both techniques are much superior to repeated use of one chemical, or a heavy dominance of one chemical in the disease control program. Mathematical models have predicted that the most efficient means for delaying or preventing the development of resistance is to alternate the use of a surface protectant with a tank mixture of a protectant and a systemic. The next best program is to repeatedly use a mixture of protectant and systemic fungicides, but a disadvantage is that an unduly long selection pressure may exist if the systemic is considerably more persistent than the surface protectant. Also of high efficiency is the alternated use of a systemic and a protectant, and the worst case is the repeated use of a systemic alone. Although mixtures of high and low risk systemics, with different modes of action, are possible, a danger exists that a fungal population can become resistant to both chemicals.

The use of alternated surface protectants and systemics, or mixtures of these types, can be improved further by using different protectants and/or systemics as the season progresses. But this is only feasible if systemic compounds with similar modes of action are avoided. Alternating benomyl with thiophanate would not be suitable, as is also the case for iprodione with vinclozolin, or triadimefon with propiconazol, prochloraz or fenarimol.

Finally, the very best resistance avoidance technique and the least costly approach to disease control is to integrate chemical control strategies with cultural management approaches. Maximum use of plant cultivar or species mixtures will enable the manager to fully utilize their disease resistance attributes. Likewise, management approaches that reduce disease incidence and lessen the chemical requirements will assist in avoiding resistance. Similarly, increased use of disease forecasting procedures will complement the disease monitoring already performed visually by most professional turfgrass managers. Such procedures will assist in reducing the desire (need?) for preventative applications of fungicides.

Tank Mixtures. The guidelines governing mixtures of fungicides in a sprayer deserve special mention. Carefully follow manufacturers guidelines regarding the compatabilities of chemical formulations. Small tests of any specific mixture should be made before using it extensively. Briefly, two or more wettable powder formulations usually can be mixed together safely. A single soluble fungicide can normally be mixed with one or more wettable powders. Examples of the soluble surface protectants include cycloheximide, fenaminosulf, and some cadmium and mercury fungicides. Emulsifiable concentrates, nematicides, herbicides, fertilizers and lime are generally not mixed with one another or with other fungicide formulations.

FATE IN THE ENVIRONMENT

All chemicals applied to the environment are destined to predictable fates; they are ultimately reduced from complex molecular structures to simple molecules of carbon dioxide, nitrogen, sulfur, chlorine, and various metallic elements such as manganese, zinc, cadmium, mercury and others. The time required to reach these destinies varies tremendously, and depends upon the chemical molecular structure and the chemical, physical and microbial characteristics of the foliage, soil and atmosphere. It is well beyond the scope of this paper to discuss these topics. This treatise will, therefore, be restricted to a descriptive discussion of simplified pathways that the chemicals and their metabolites follow on plants and in soil (refer to the illustration). Molecules that are misapplied so as to reach a body of water or to drift away in aerosol-size or larger droplets are not included in this discussion.

When a suspension of fungicide leaves a sprayer nozzle, the initial deposition will be on the surfaces of foliage or surface litter (thatch). In very young or thin turf, the chemical may also land first on the mineral soil surface. The chemical is first adsorbed onto these surfaces and may then follow a complex series of physical and chemical pathways. Through the entire sequence, chemical molecules may be decomposed to simpler metabolites by microbial degradation, chemical degradation, or photolysis (decomposition by light).

Only three pathways are possible for surface protectants adsorbed on leaf surfaces. The most important of these is the return of chemical to the thatch surface when treated leaf tips are mowed off and left on the area. Obviously, if clippings are removed from treated areas, the chemical may serve as a contaminant in any area where the clippings are dumped. Wind, water and abrasion may erode some chemical from treated leaves, and redeposit the chemical into thatch or soil. Some chemicals may also have sufficient vapor pressure to enable slight volatilization, and the vapor may be blown away, or re-adsorbed onto nearby surfaces.

Once the surface protectants reach the thatch or soil they no longer efficiently serve their intended role as fungicides. Final phases of pesticide decomposition are likely to be in thatch or soil. Fungicides can be degraded by microorganisms or by chemical processes. Minor amounts of water-soluble fungicides may leach below the root zone in sandy soils, but most fungicides are rather insoluble and adsorb to clays and organic materials and, therefore, do not leach. Leaching studies with benomyl have shown that the chemical is nearly all retained in the upper 4 cm in all soil types. It is also unlikely that erosion of soil or clippings, with adhering fungicide, will transmit fungicides from mature turfgrasses. But soil erosion is possible on newly seeded areas.

Systemically translocated fungicides are subject to a complex group of possible pathways in the turfgrass environment. In addition to those described for surface protectants, these compounds are subject to redistribution within plants and in soil. As before, the final place of decomposition is in the thatch or soil. Since roots can absorb systemics from soil or thatch, it appears possible that at least some of the chemical can be effectively recycled until the material lodges in areas inaccessible to roots, or until the fungitoxic molecular structures are decomposed. Chemicals translocated acropetally can emerge as exudates from leaf edges and leaf tips. Such exudates are called guttation droplets, and can be readsorbed on the leaf, or washed back toward the soil or thatch. Likewise, it appears that basipetally translocated fungicides can be included among the root exudates, and can conceivably be reabsorbed to re-enter the acropetal flow. These cyclings could prolong the effective life of systemically translocated fungicides.

The time required for a fungicide to totally disappear from the turfgrass is extremely difficult to determine. Decomposition rates are typically illustrated in terms of the time required for half of the chemical to become inactivated from its fungitoxic forms. These half-life values are dependent upon the characteristics of the soil, climate and fungicides. Several examples serve to illustrate the variability in this process. In a moist silt loam, the half-lives of anilazine and captan are 1 hour and 4 days, respectively. In the same soil, kept dry, the half-lives for these chemicals jump to about 3 and 70 days, respectively. Half-life measurements for benomyl and metalaxyl have been shown to vary from 12 to 52 weeks and 5 to 25 weeks, respectively. The life of metalaxyl is highly dependent upon soil pH, organic matter content and oxygen concentration; it is longest in alkaline, very wet, highly organic substrates. With these variations in mind, some anticipated or potential half-lives (in weeks) can be listed as follows: less than 1, anilazine; 1-10, captan furmecyclox, oxycarboxin, thiram; 11-20, phosethyl A1; 21-30, metalaxyl; 31-52, benomyl, fenaminosulf, quintozene, triadimefon. These are reasonable estimates and will vary considerably in different seasons and turfgrass management programs.

NONTARGET EFFECTS

Fungicides should only be applied to control diseases or to prevent predictable occurrences of reoccurring diseases; such diseases are the TARGET of each application. Effects of the fungicide application on other diseases or other processes are called NONTARGET EFFECTS. The nontarget effects can be beneficial or deleterious and, whenever possible, should be considered among those factors governing the fungicide selection or purchasing decision process. In this way the turfgrass manager can exploit desirable nontarget effects and minimize the undesirable effects, or at least be aware of the need to adjust management programs to compensate for the negative effects.

The following discussion is based mostly upon the author's findings during a decade of fungicide research at Cornell University. The dialogue is separated into nontarget effects of fungicides on the microorganisms in thatch and soil, on the chemistry of soil, on growth of plants, and on thatch accumulation.

Microorganisms. Plant pathogenic fungi are vastly outnumbered in thatch and soil by nonpathogenic components of the microflora (bacteria, actinomycetes and fungi) and microfauna (amoeba, nematodes, tiny insects, etc.). All members of these populations compete for nutrients and, therefore, interact with one another in an extremely complex ecosystem. It is the complexity of these interactions which keeps the system in equilibrium. The balances among organisms can become skewed by fungicides because fungi are a major component of the microbial life in soil and thatch. Fungicides not only suppress activities of those fungi which cause a target disease, they also affect many other sensitive fungi in the ecosystem, and sometimes other groups of microorganisms as well. When activities of sensitive organisms are suppressed by residues of a fungicide, a simultaneous increase occurs in populations of resistant organisms, so that the supply of nutrients stays at population-limiting concentrations.

Fungicides are unlikely to greatly alter the total biomass of each microbial group in soil or thatch. Considerable changes in fungal species occur in heavily treated areas, but the total populations of fungi, bacteria and actinomycetes are likely to remain relatively steady. The largest shifts in microbial populations occur when two or more broad spectrum fungicides are used in tank mixes or alternately. As more fungicides become involved in the disease control program, the total population of fungi is reduced somewhat is is replaced by additional bacteria and actinomycetes. Sporulation and activities of resistant fungal species are sometime increased in response to reduced competition from sensitive fungi.

These changes in fungal species can have profound effects on the subsequent expression of turfgrass diseases. Active growth of many pathogenic fungi is suppressed by parasitism or antibiotic production by nonpathogens. If the nonpathogens are more sensitive to a fungicide than is the pathogen, the application of that fungicide can lead to further outbreaks of the disease. If the nonpathogens are less sensitive than the pathogen, the applied fungicide and the nonpathogens interact to further suppress the pathogen, resulting in an integration of biological and chemical controls. When such instances occur, the efficiency of control from the fungicide is related directly to the microbial composition of the soil or thatch. These effects consider the occurrence of only one pathogen in the turfgrass. It is generally true, however, that as many as five potentially pathogenic fungi can be isolated from every turfgrass ample. When a fungicide is applied to control a single recognized disease, it is also possible that a second disease may become established or be amplified into recognizable proportions. In this way, a fungicide may cause a trading of diseases.

I have reviewed elsewhere (Smiley, 1981) some technical papers which reported over 90 examples of turfgrass diseases which have been increased as a result of fungicide applications. An abbreviated account follows: Rhizoctonia brown patch, stripe smut and red thread are diseases caused by basidiomycete fungi, and are known to have been increased occasionally by applications of benomyl, chloroneb, cycloheximide, propiconazol, quintozene, thiophanate or thiram. Fusarium patch has been increased by maneb, thiram, anilazine, chlorothalonil and etridiazole. Fusarium blight was amplified by anilazine, chlorothalonil, propiconazol, and quintozene. Rusts, *Drechslera* leaf spot, fairy rings, red thread, Typhula blight and Pythium diseases have all been increased by benomyl and the thiophanates. Dollar spot has been increased by quintozene, maneb, mancozeb, thiram, anilazine and, in one instance, by chlorothalonil. Drechslera leaf spots may also be amplified by heavy metal fungicides, thiram, chlorothalonil, and triadimefon. It is highly unlikely that each of these examples will every occur at one site; they are reviewed here to illustrate the demonstrated potential for fungicide-induced increases in diseases to actually occur. Most instances have been recorded on replicated research or demonstration plots where actual disease comparisons can be made and quantified. Large, uniformly treated areas, such as golf greens or fairways, could undoubtedly reveal many more examples if adequate nontreated strips could be left for comparison. Examples must be selected carefully to avoid the all-too-common error of misdiagnosing the causes of diseases that have similar symptoms but different pathogens.

Benomyl and thiophanate have also become recognized for their ability to inhibit reproduction of some nematodes and mites, and to inhibit the activity of earthworms. Since each of these fuanal groups are involved in litter decomposition, it may be anticipated that the fungicides could interfere with thatch decomposition. Nematodes, for instance, are mostly (95%) nonpathogenic, and the productivity of many grasslands is correlated with nematode numbers; greater productivity occurs where the highest total nematode population exists, provided the pathogenic types are not favored by sandy substrates and monoculture of grass species.

Soil Chemistry. Enzymes necessary for many biochemical processes are affected by fungicides. Studies of nontarget effects of fungicides on these systems have not been made in turfgrasses. We have, however, studied the nitrification of ammonium to nitrate-nitrogen in fungicide-treated turf. Although the nitrification process is known to be extremely sensitive to fungicides uniformly mixed into soils, we have found no evidence that high rates and frequencies of fungicide applications, over many years, can suppress nitrification in turfgrasses.

Frequent applications of some fungicides caused the turf to become more acidic. Notable among the acidifying fungicides were benomyl, maneb and thiram. Related chemicals were not tested, but would be expected to also produce acidity in turf. Lower frequencies of application have shown that little or no acidity was induced; this is, therefore, a potentially negative effect of using these chemicals more than 5 to 10 times per season on high quality areas such as golf greens. It is thought that the acidifying properties are contributed by acidic ''inert'' ingredients of the formulations, and by the nitrogen and sulfur released during decomposition of the active ingredients.

Plant Growth. All fungicides can obviously improve plant growth if they control diseases that have reduced the growth rate, and can reduce plant growth when applied at phytotoxic rates. Systemically translocated fungicides may also have additional, more subtle influences on plant growth, as a result of their effects on plant physiology. The systemics are best separated into two groups for discussion purposes; benzimidazole-derivative and sterol-biosynthesis inhibiting fungicides.

Benzimidazole derivatives such as benomyl and thiophanate are structurally very similar to plant hormones called cytokinins. The fungicides can substitute for cytokinins in plants, and treated plants may, therefore, exhibit effects of hormonal stimuli. These effects may result in a delay in tissue senescence, such as increases in retention of chlorophyll and in leaf growth rates. It has been speculated that the benomyl-induced reduction in enzyme activities in seedlings may also result in a decrease in resistance to attack by some foliage pathogens. This is seemingly the case with rust and leaf spot diseases.

Sterol-biosynthesis inhibiting fungicides include a chemically diverse group of compounds with triazole, pyrimidinemethanol, and other molecular configurations.

Ergosterol is an essential sterol in fungi, and the blockage of its synthesis by these fungicides occurs at a point that is identical to a biochemical step leading to gibberellin (a hormone) synthesis in plants. As with the benzimidazoles, the sterol-biosynthesis inhibitors can thereby affect the hormonal balance in plants. The effects in this case include reduced rates of growth in leaves, rhizomes and roots, reduced tiller density and, in some instances, reduced germinability of seed on recently treated soil. Increases may also occur in chlorophyll retention and production (resulting in deeper green leaf color) and in nonstructural carbohydrates. Higher levels of carbohydrates enable treated plants to successfully resist effects of drought, heat and related stresses. It is not surprising, therefore, that some of these fungicides are used commercially to increase survival of cereal plants during dry summers, and that some are recognized for their ability to indirectly reduce summer diseases of cool-season grasses. The fungicides in this general group include fenarimol, triadimefon, propiconazole, and prochloraz. Some of these fungicides are closely related to chemicals sold as plant growth regulants. When used as registered, these fungicides are quite safely applied to turfgrasses. But their abuse is likely to cause impaired growth that can only be reversed with frequent foliar applications of gibberellins.

Iprodione's mode of action is poorly understood, but it too increases chlorophyll retention. We have measured large increases in tiller density, leaf production, rhizome growth, and root production in iprodione-treated plots during the spring, and the absence of such effects during summer on non-irrigated turf.

Thatch. A dramatic attribute of some fungicides is their ability to increase thatch (or mat) depths in turfgrass. This only occurs when frequent applications are made over two or more years. Fungicides that have induced thatch in my long-term studies include benomyl, cadmium, succinate, iprodione, maneb (mancozeb), thiram, and thiophanate. The nematicide fenamiphos (Nemacur) was also used, and also caused thatchiness. Combinations or alternated uses of these materials further aggravated the thatch accumulation process. Applications of the chemicals were made nine times each season, or fewer when used alternately during every second or third application made to a plot area. The nematicide was used only once each season. Subsequent studies with only three applications each season have failed to show that fungicides induced thatch, and seven applications each year caused intermediate effects.

Some fungicides do not seem to cause thatchiness. Plots frequently treated only with anilazine, captan, chlorothalonil, cycloheximide, etridiazol or quintozene have never had more thatch than that in the nontreated controls in my studies.

The causes of thatch accumulation in fungicide-treated turfs involve a complex group of poorly understood effects. Some of the effect appears to result indirectly from acidification in the thatch layer. Microbial decomposition is highly related to pH, and is reduced in acidic substrates. Part of the thatch induction also appears related to suppressed growth of nematodes and some groups of fungi that are especially active as decomposers or organic litter. But much of the effect is now known to result from increased rates of plant growth, without corresponding increases in the decomposition rate. Fungicides that reduce growth of roots and rhizomes tend to also reduce the thatchiness of turf. Although the precise mechanisms remain unclear, it is certain that the fine balance between plant tissue production and decomposition are tipped in favor of the production and, therefore, accumulation by some fungicides that may be used at excessive rates or frequencies.

CONCLUSIONS

Many characteristics of fungicides have been presented in this paper. These remarkable disease control chemicals have an important role in turfgrass management programs which must be improved continually to fully implement the current state of knowledge and technology. In this way we can devise and implement the least costly and least disruptive approaches to managing healthy turf. Pesticides, grass varieties and species, and cultural practices must be integrated into a fine network of year-around management. Neglect in any one component of the system will surely lead to unnecessary expenses and possibly to embarrassing exposures of poor management technique. Additional references for more technical readings on the subjects presented here are listed below.

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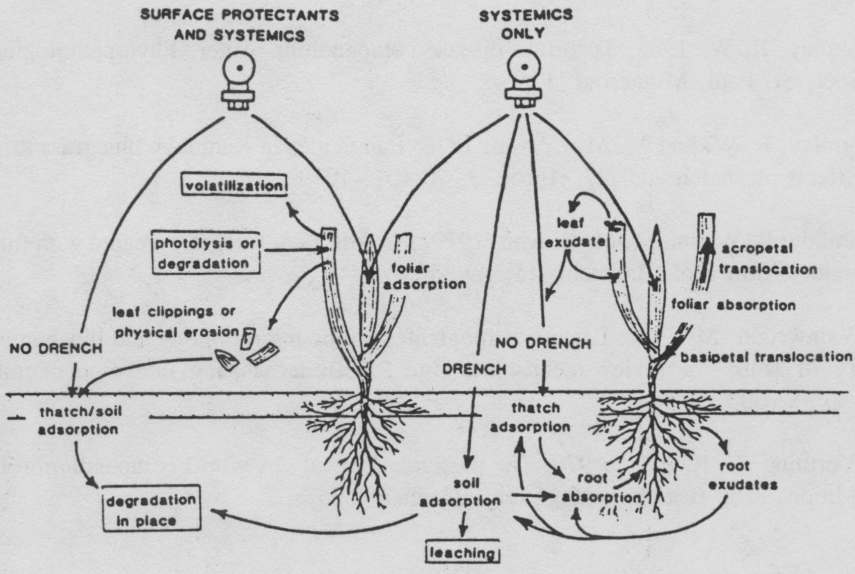

FATES OF FUNGICIDES IN THE TURFGRASS ECOSYSTEM

Table 1. Protectant fungicides used to control turfgrass diseases

Classification	Common Name	Trade Name	Solubility in water (per L.)
Broad-spectrum Surface Protectants	anilazine*	Dyrene, Scott's No. III	< 1 mg
	cadmiums, inorganic	Cad-ex, Caddy	1.5 kg
	cadmiums, organic	Cadminate	<10 g
	captan	Captan, Orthocide	3 mg
	chlorothalonil*	Bravo, Daconil, Scott's 101V	1 mg
	maneb	Tersan LSR	< 1 mg
	mancozeb	Dithane M-45, Fore	< 1 mg
	mercurous chloride*	Caloclor, Calogran	2 mg
	phenylmercuric acetate	PMA	4 g
	phenylmercury dimethyldithiocarbamate	PMAS	6 mg
	thiram	Thiram, Tersan 75, Spotrete	30 mg
	zineb	Zineb	10 mg
Narrow-spectrum, Locally Systemic Protectants	chloroneb*	Tersan SP, Scott's No. II	8 mg
	cycloheximide	Actidione TGF	21 g
	etridiazole (ethazole)	Koban, Truban, Terrazole	50 mg
	fenaminosulf	Dexon, Lesan	25 g
	quintozene*	PCNB, Terraclor, Scott's FFII, Lawn Disease Preventor	< 1 mg

*Products formulated as granulars as well as wettable powders.

Table 2. Systemically translocated fungicides used to control turfgrass diseases

Spectrum of Activity	Common Name	Trade Names	Movement[+]	Solubility in water (per L)
Broad	benomyl*	Benlate, Tersan 1991	A1	4 mg
	fenarimol	Rubigan	B1	14 mg
	iprodione*	Rovral, Chipco 26019, Scott's No. VI	A2, B?	13 mg
	prochloraz**	Sportak	B1	47 mg
	propiconazol	Tilt, Banner	B1	110 mg
	thiophanates*	Fungo, Topsin M., Scott's Systemic	A1	<20 mg
	triadimefon*	Bayleton, Scott's No. VII	B1	260 mg
	vinclozolin	Ronilan, Vorlan	A2, B?	1 g
Narrow	benodanil**	Benefit	B1	20 mg
	furmecyclox**	Camprogran, Epic	A1	250 mg
	metalaxyl*	Ridomil, Subdue	B1	7 g
	oxycarboxin**	Plantvax, Ring Master	A1	1 g
	phosethyl Al	Aliette	B1	122 g
	propamocarb	Previcur, Banol	A1	700 g

*Products formulated as granulars as well as wettable powders.
**Products not commercially available at the time of manuscript preparation.
+Translocation (A) acropetally or (B) both acropetally and basipetally, and (1) rapidly or (2) slowly in the acropetal direction.

LESSER KNOWN DISEASES OF PUTTING TURF IN THE PACIFIC NORTHWEST[1]

Gary Chastagner[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
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There are four diseases which commonly occur on putting turf in the Pacific Northwest. These are Fusarium patch, Typhula snow mold, Take-all patch and red thread. Most of the putting turf disease research that has been done in the Pacific Northwest has focused on the control of these diseases. In addition to these diseases, there are other diseases of putting turf that for one or more reasons are not as common in our area.

These lesser known diseases that I would like to briefly discuss this morning are anthracnose, Rhizoctonia brown patch and yellow patch, Red leaf spot, yellow tuft, Basidiomycete rings, a problem we call albino *Poa annua*, and southern blight. More detailed information on most of these diseases can be found in the American Phytopathological Societies *Compendium of Turfgrass Diseases* which was prepared by Dr. Richard Smiley. This 102 page publication is available for $15.00 from the American Phytopathological Society Office at 3340 Pilot Knob Road, St. Paul, MN 55121.

ANTHRACNOSE

The first disease is anthracnose caused by fungus *Colletotrichum graminicola*. This is primarily a disease of stressed *Poa annua* turf. Under cool conditions, symptoms consist of lesions on stems which girdle the plant causing small patches or scattered individual yellow plants which prematurely die. Oblong, reddish-brown leaf lesions followed by leaf yellowing and browning can occur under high temperatures when the soil is dry and there is high relative humidity. Typically these symptoms occur on older leaves.

Conditions favoring disease development consist of stresses, including temperature extremes, compacted soils, inadequate phosphorus, potassium, nitrogen and soil moisture. A moisture film on the foliage is necessary for infection thus, the disease is favored by periods of high relative high humidity or excess water on the turf.

This pathogen probably survives periods that are unfavorable for disease development as mycelium in infected plant debris. Under conditions favorable for disease development, the pathogen produces conidia in fruiting bodies, called acervuli, on necrotic tissue. These conidia are spread by water and wind from plant to plant.

Reducing stress is the key to controlling anthracnose. This can be done through the use of a balanced fertility program, and by maintaining adequate fertility and soil moisture levels. There are several fungicides such as Fore, Tersan 1991 and Bayleton which have been shown to be effective in controlling this disease. Check and read labels prior to the use of any of these materials.

RHIZOCTONIA BROWN PATCH AND YELLOW PATCH

There are two diseases caused by different species of *Rhizoctonia* that can occur on putting turf in the Pacific Northwest. These are brown patch caused by *R. solani* and yellow patch caused by *R. cerealis*. The development of brown patch is favored by high temperatures and relative humidities and is generally not a problem in the Pacific Northwest because of our mild temperatures. Yellow patch develops at lower temperatures and is probably more likely to occur in our area than brown patch.

Typically, the symptoms of brown patch occurred during summer and early fall. They appear as small to 20-inch in diameter circular to irregular shaped patches of blighted turf. The blighted turf is purplish green initially, but quickly fades to a light brown color. During periods of warm, humid weather, a dark purplish or greenish brown border, called a smoke ring, may appear around the patch.

Yellow patch symptoms generally appear from fall through spring and consist of light brown to yellow rings or patches. During periods unfavorable for disease activity new leaves will emerge from surviving plant crowns, stolons and rhizomes.

Besides the differences in temperature for disease development, these pathogens can be separated on the basis of the number of nuclei they have in their hyphal cells. *Rhizoctonia solani* is multinucleate, whereas *R. cerealis* is binucleate.

Conditions which favor disease development are prolong periods of leaf wetness due to humid weather, poorly drained thatch, cloudy weather and a dense highly fertilized and watered turf. These pathogens survive unfavorable conditions as mycelium in plant debris and as small resistant structure called "bulbils" which are usually found in the thatch layer. Disease spread usually occurs from plant-to-plant spread of mycelium, but may also occur from spores produced by the sexual stage of these fungi.

Control of these diseases consist of maintaining a balanced fertility program, avoiding applications of excess nitrogen during periods favorable for disease development. Improving drainage, reducing thatch levels and minimizing periods of free moisture on leaves are also important control measures. There are many fungicides available for control of brown patch. Most of these materials are not effective against yellow patch. Fungicidal control of yellow patch has been erratic with most materials. Applications of mercury fungicides may be helpful in controlling this disease.

RED LEAF SPOT

Red leaf spot occurs on bentgrass turf and is caused by *Drechslera erythrospili* (*Helminthosporium erythrospilum*). This disease generally occurs during warm, moist weather and symptoms appear as small brown to reddish brown leaf lesions. Lesions coalesce to give affected leaves a reddish appearance. Diseased plants occur in patches or scattered throughout the turf. Symptoms can be confused with moisture stress.

Warm, moist weather favors disease development. Prolonged periods of free moisture on leaves, low mowing height, stress, low light intensity, excess nitrogen, the use of hormonal or systemic pesticides and excess thatch also favor disease development.

This pathogen survives periods which are unfavorable for disease development as mycelium in plant debris or as conidia. It can also grow saprophytically on dead plant material. Under favorable conditions, large numbers of conidia are produced on the dead plant material and initiate infection of healthy leaves. Conidia produced on these leaves are spread by wind to adjacent healthy plants.

Control of this disease consists of maintaining a balanced nutritional program, proper water management, avoiding the overuse of hormonal and systemic pesticides, removal of excess thatch and promoting air movement. Several fungicides are also available for control of this and other Helminthosporium-type leaf spots.

YELLOW TUFT

Yellow tuft, or downy mildew, is a disease caused by the obligate parasite *Sclerophthora macrospora*. Symptoms are most prominent during late spring and fall. Initially they consist of stunted, slightly thickened or broadened leaf blades. Severe disease results in small one-half to 5-inch in diameter yellow patches. Patches on bentgrass tend to be of the smaller size. These patches consist of dense clusters of excessively tillered, yellowed shoots with few roots. The mildew stage is not always present on infected plants. This disease is favored by excess moisture and usually occurs on turf in poorly drained or heavily water areas.

The fungus survives as oospores in infected plant debris. The disease is spread by zoospores which are produced by sporangia on leaves and from germinating oospores. Control of this disease involves providing adequate drainage. Avoiding mowing wet turf will minimize the spread of this disease. Dr. Noel Jackson, at the University of Rhode Island, indicates that applications of Subdue at 2 oz per 1000 ft^2 have been effective in controlling this disease. Other fungicides which are also active against *Pythium* are also likely to control this disease.

BASIDIOMYCETE PATCHES

Basidiomycete rings or patches is a disease problem which occurs on putting turf in the Pacific Northwest. These are probably a type of fairy ring. Symptoms appear as circular patches or rings of dark green turf up to 2 feet in diameter. These areas tend to be slightly depressed, probably due to decomposition of thatch beneath the patch by the fungi causing this problem. In most instances, mushrooms and toadstools are not associated with symptomatic turf, although a dense, coarse white mycelium is usually present in the thatch layer beneath the patch. Basidiomycete fungi are likely to be the cause of this problem although we have isolated a fungus called *Sphaerobolus stellates* from bentgrass turf with these patches in Puyallup.

Some control of this problem may be obtained by removing excess thatch and maintaining adequate fertility levels to mask symptom development. Top dressing may be necessary to maintain an even putting surface. The effectiveness of fungicides such as Bayleton which have good activity against some basidiomycetes is unknown.

ALBINO *POA ANNUA*

This next problem may or may not be a disease. It is a condition we refer to as albino *Poa annua*. Typically, symptoms consist of slightly yellow to mostly white leaves on *Poa annua* plants. Affected leaves lack chlorophyll. Affected plants occur in small patches usually less than 6 inches in diameter or scattered throughout the turf. Symptoms have been observed on turf at various times of the year although spring is a common period in which symptoms occur. We have not been able to isolate any organism from symptomatic leaves. Removal of cores with symptomatic turf and placement in a greenhouse results in rapid recovery of the affected plants. The cause of this problem, conditions which favor its development and effective control measures are unknown at the present time.

SOUTHERN BLIGHT

The last disease I will briefly discuss is a disease which probably does not occur in the Pacific Northwest. This is southern blight caused by *Sclerotium rolfsii*. This disease occurs in areas with high temperatures. Symptoms are yellow, circular to crescent shaped areas up to 10 inches in diameter. Patches enlarge rapidly during hot, humid weather resulting in rings of dead, brown grass 3 to 6 feet across. The fungus survives a sclerotia which germinate at temperatures above 70°. Excessive thatch, undernourished turf, and low pH tends to favor disease development during periods of hot, humid weather.

The symptoms of this disease resemble those of take-all patch which is a common disease of putting turf in the Pacific Northwest.

Control of southern blight depends on reducing excessive thatch, liming to maintain soil pH levels above 8, and maintaining adequate fertility. Applications of the fungicide PCNB have also been effective in controlling this disease.

WHAT ARE GOOD SEED SPECIFICATIONS?[1]

William A. Meyer[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Turf-Seed, Inc., Hubbard, OR.

Good seed specifications must clearly indicate the genetic quality and mechanical purity of seed that is needed to establish a high quality turf. It is very shortsighted to purchase anything but high quality seed to established a perennial turf. The new improved turfgrasses now available are capable of performing well over a long period of time if they don't start out by being contaminated by undesirable crop and weed seeds.

GENETIC QUALITY

When specifications are written, it is very important to choose varieties well adapted to the uses and management intended for a new turf area. Data on varietal performance can be obtained from local University and private turf evaluation programs or from the National Turfgrass Evaluation Program coordinated by the USDA in Beltsville, Maryland.

Varieties specified should have good performance records over a number of years, preferably in more than one trial. Caution must be used to compare the management used for the trials to the management intended for the new turfgrass area. For example, a creeping or hard fescue variety might have an excellent performance record in a moderately fertilized trial mowed at 1/2 inch, but very poor potential in a high-traffic fairway mowed at 1/2 inch.

Other important sources of information are the professional turfgrass managers in an area. They can furnish observations on the performance of turfgrasses under traffic conditions that are not a factor in many turf trials.

Once varieties have been chosen, it is important to specify only varieties grown under a Seed Certification Program such as that of Oregon State University. Certified seed must have an official seal and certification tag on each container whether it is a single variety or a mixture. The purchase of certified seed is an assurance to the buyer of the genetic integrity of the seed. The certification officials enforce regulations that have been developed to control the genetic quality of seed production.

There are many turfgrass varieties and species commercially available today as a result of extensive turfgrass breeding in the past 15 years. It is now possible to develop blends and mixtures of varieties that offer greater genetic diversity to combat disease and insect problems in nature. Varieties and species should be combined that have complimenting qualities. For example, the new hard fescue varieties can enhance red thread resistance in mixtures with the more wear tolerant perennial ryegrasses.

SEED PURITY

The quality of seed in specifications should at least meet the minimum standards for Oregon Certified Seed (Tables 1 and 2). They should also prohibit the presence of those crop and weed seeds that cannot be controlled by selective herbicides. Some of the grasses listed as other crop on a seed test and label can be serious weeds when present in the fine textured turfgrasses much as Kentucky bluegrass, perennial ryegrass and fine fescue. Some of the most undesirable crops in the above turfgrasses are creeping or colonial bentgrass, rough bluegrass (*Poa trivialis*), orchardgrass, timothy, tall fescue and meadow fescue. Orchardgrass, bentgrass and rough bluegrass are serious weed problems in the new turftype tall fescues. Some of the undesirable species listed in the weed portion of the seed label are annual bluegrass, quackgrass and velvetgrass. Many times the weed and other crop content in a seed label is not defined and can only be obtained by getting a copy of the official seed test. It is possible that certified seed may contain low levels of some of the above undesirable other crop and weed seeds. It is possible to request that seed meet sod quality standards or, in the case of Penncross, that it meet putting green quality standards (Table 3).

The writer of seed specifications should choose the best varieties and species for each area and use, specify only certified seed with tags and seals on each container, and prohibit undesirable weed and crop seeds. If these simple guidelines are followed, the chances of developing a high quality turf should be greatly improved.

Table 1. Oregon certification minimum seed standards for Penncross and Penneagle creeping bentgrass and Kentucky bluegrass.

Percent	Creeping bentgrass Penneagle	Creeping bentgrass Penncross	Kentucky bluegrass America and Merion	Other varieties
Pure seed	98.00	96.00	92.00	95.00
Other crop	0.50	2.00	0.25	0.25
Inert	2.00	4.00	8.00	5.00
Weed seed	0.10	0.25	0.30	0.30
Germination	85.00	80.00	75.00	75.00

Table 2. Oregon certification minimum seed standards for fine and tall fescues and perennial ryegrass.

Percent	Fine fescue	Tall fescue	Perennial ryegrass
Pure seed	97.00	98.00	99.00
Other crop	0.25	0.50	3.50*
Inert	3.00	2.00	1.00
Weed seed	0.30	0.30	0.50
Germination	80.00	90.00	90.00

* Crops other than ryegrass .50, other ryegrass maximum is 3.00.

Table 3. Oregon sod quality standards and the putting green standards for Penncross from Tee-2-Green, Inc.

Kind	Minimum purity	Minimum germination	Maximum[1] other crop	Maximum[5] weed
Perennial ryegrass	98%	90%	0.1%[2]	.02%
Merion Kentucky bluegrass	95%	80%	0.1%[3]	.02%
Other varieties of Kentucky bluegrass	97%	80%	0.1%[3]	.02%
Red fescue	98%	90%	0.1%	.02%
Chewings fescue	98%	90%	0.1%	.02%
Bentgrass	98%	85%	0.1%[4]	.10%
Tall fescue	98.5%	90%	0.1%	.02%

[1] Must be free of ryegrass, orchardgrass, timothy, bentgrass, big bluegrass, *Poa trivialis*, smooth bromegrass, Reed canarygrass, tall fescue and clover. (When the base sample is one of these kinds, the species will not be considered a contaminant; ie. ryegrass in ryegrass.)

[2] Certification fluorescence levels and appropriate calculations will be applied when determining levels of other crop.

[3] Maximum other varieties of Kentucky bluegrass allowed is 2%; maximum allowed Canada bluegrass is .02%.

[4] A 500-seed count will be used to determine other species of *Agrostis*.

[5] Must be free of dock, *Rumex* spp.; chickweed, *Cerastium* spp.; and *Stellaria media*; crabgrass, *Digitaria* spp.; plantain, *Plantago* spp.; black medic, *Medicago lupulina*; annual bluegrass, *Poa annua*; velvetgrass, *Holcus* spp.; and other "All-state" noxious weed seeds.

Putting Green Quality for Penncross

Pure	98.00%	Germination 85.00%
Crop	0.10%	
Inert	2.00%	Free of all noxious and objectionable
Weed	0.10%	weeds including *Poa annua*.

TIPS ON MAINTAINING BASEBALL INFIELDS[1]

Michael D. Hebrard[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Hobbs and Hopkins, Inc., Pro-Time, Portland, OR.

FIELD PREPARATION

It really helped me to have been associated with all levels of play in understanding what play conditions a groundskeeper should strive for.

By far, the biggest problem is in the preparation and maintenance of the pitchers mound. The mound should be packed, moist, and smooth in order to allow for the pitcher's best performance and ease of maintenance. By the mound being packed, water is able to run off the pitching area more effectively; by being moist the pitcher is able to get better footing and balance so he doesn't have to dig a big hole to throw out of. Also, by having the mound stay moist, it holds together better and is less likely to lose shape and fall apart. In the hot and windy months it is just as important to keep the mound covered as when it is wet. A tarp will keep in the moisture and allow the mound to hold its shape and consistency.

The same holds true in preparation of the homeplate area. If the area is kept moist so that the players can sink their cleats in while at bat, they are less likely to dig or tear out big holes while batting. Remember, it is very important to have good footing when hitting a baseball. It just cannot be done in loose, unpacked dirt. By keeping the homeplate dirt moist, a batted ball that is topped will stay down and be a potential out; whereas, a rock hard surface leads to abnormal fielding positions and cheap hits.

The base lines should be hard packed and smooth. This is a running surface and should be maintained with that understanding. A hard packed base line allows for better water run off and less absorption.

The most complained-about area is the skinned part of the infield. My experience has shown that by using only one quick connector behind the mound, the infield grass can be watered down with enough overlap to wet down the front edge of the infield dirt. This allows an infielder to get good footing while playing back. The moist area in the front portion along the grass edge tends to keep the ball down allowing the infielder to stay in the proper fielding position. By using a central watering outlet, the infield grass is more consistently watered. A one-outlet location provides the capability of a hose hookup which can be used to water the remainder of the infield.

BASE ANCHORS

There are basically two styles of base anchor stakes used for baseball and softball: 1) the bolco style in which the base fits around the stake, and 2) the hollywood model in which the base slides inside the stake.

The base anchors should be premade from concrete so that they can be installed anytime, in the case of damage or new field layout. This makes for an excellent inclement weather project for employees needing something to do. I have designed a wooden form enabling me to make three (3) such anchors at one time, fitting any size or style of stake that is desired. With my particular form two (2) 90 lb bags of pre-mix concrete provides the correct amount of material to make all three base anchors required for each field. My form is designed so that each anchor is 15 x 15 inches square (the same size as the base) allowing a groundskeeper to install the anchor without searching for where the base was last stored. For best results a base should be present to ensure proper placement. The stake should be made from stainless square tubing or other rust resistant material (usually a set is provided with the purchase of a new set of bases) and be at least 8 inches long. I recommend digging a place for the anchor, preferably using a square point shovel so that there is plenty of room to move the anchor in all directions for adjustment and so that the top of the stake is installed at 1 inch below ground level. Once the hole is dug, spread a small amount of sand on the bottom to allow for easier alignment of the stake. A torpedo level should be used to ensure that the stake is perfectly straight up and down. I recommend keeping a plug on the stakes when the bases are not in use for two reasons: 1) ensuring that dirt doesn't build up under the base; and 2) making it easier to find the stake when installing the base before a game. Bases should never be left on the field. They tend to get waterlogged and weathered, thus shortening their life span.

LAYING OUT THE FIELD

The following is a list of equipment necessary for proper field layout.

1. Steel pipes (4) used for permanently marking out the homeplate, each foul pole, and dead center

2. Transit and pole to shoot angles and cross check measurements of bases

3. Base anchors (3)

4. Homeplate 4 inches thick (flat for recreational only)

5. Pitchers rubber (four-sided or thick one)

6. Nylon cord 3/8 inch x 400 feet

7. Gutter nails to mark spots and hold ends of cord and tapes

8. Tape measures 100 feet (2) and 150 feet (1)

9. Chalk string to mark centerline on rubber and homeplate

10. Pick and/or pointed shovel to break dirt up only

11. Square pointed shovel to cut out flat surface and edges

12. Sand to lay under anchors, homeplate, and rubber

13. Torpedo level to level all anchors, homeplate, and rubber

14. Yard stick to check for stake clearance and mound height

15. Line level to check height of mound

16. Stomper to pack loose dirt around

17. Landscape rake to work and level off areas

Locate center of backstop and triangulate the center of field. Drive pipe inground where the apex of homeplate is located. Plumb bob the pipe with the transit. Shoot out to the center of field and drive a pipe next to base of outfield fence. Run cord from home to center and snap. Break transit 45 degrees to left and shoot pipe for left field foul pole and break 90 degrees to right and shoot pipe for right field foul pole. Leave transit in place for cross checking. Measure distance to second base and install base anchor. (Remember, you lose about 2 inches of tape traveling over the mount.) Cord can be moved to side while working in that area and replaced to check. Cord should run straight over stake. Make sure stake is in the correct alignment and that the measurement is to the center of the stake. Measure the pitchers rubber in front edge, center and level. Now measure home to third and second to third. Install anchor (measurement to the back of the base and anchor inside of the foul line). Check location with transit. Repeat for first base. Cross check with transit and measure far corner of third to far corner of first to verify how accurate you are. Believe it or not, homeplate is the last thing I put in place. Center, level, and work homeplate area.

MOWING

Mowing the infield of a baseball field varies drastically according to the grass, equipment, and groundskeeping personnel. I recommend mowing the infield grass at least twice a week to allow for more consistent roll (since most infields have many different varieties of grasses present that grow at different rates) and not allow the grass to get too long. I prefer a good sharp power walk-behind reel mower to all others. However, a sharp rotary mower will suffice. I do not recommend riding-type mowers on infields because this leads to compaction and large amounts of grass clippings, as well as the mower crossing over marked baselines in order to make its turns. I also recommend an infield mowed in a cross pattern (home to first and home to third; or home to second and first to third). However, if time does not permit cross mowing, then mow home to second only. This will give the infield a balanced look and be aesthetically pleasing.

FIELD PROTECTION

The best development in recent times is the number of portable fence panels. These panels are designed for the outfield fence during the season and are moved in around the infield during the fall and winter months to protect the infield from unauthorized use as well as protection while renovating the infield grass area. Make sure the fence is made of a heavy gauge wire with a welded frame ensuring longevity as well as infield protection.

The effectiveness of using signs around the playing field is uncertain. Give yourself the opportunity to educate the public of your desires (i.e. no softball, bicycles, pepper games). Let the signs point out where such activity is permitted. Also, indicate fence dimensions, the number of the field, and even the field name. It is always nice to hear a parent brag about Johnny hitting one over the 340′ sign at Central Park on Field 3.

GROUNDSKEEPING PHILOSOPHY

Baseball is the best designed sports facility ever. Where there is a high degree of traffic, dirt is used; where the pitcher throws, a dirt mound which can be reshaped easily; where the batter hits, the homeplate area; when he becomes a runner and has to slide, a dirt baseline; and when an infielder has to move quickly to field a ball, a dirt infield.

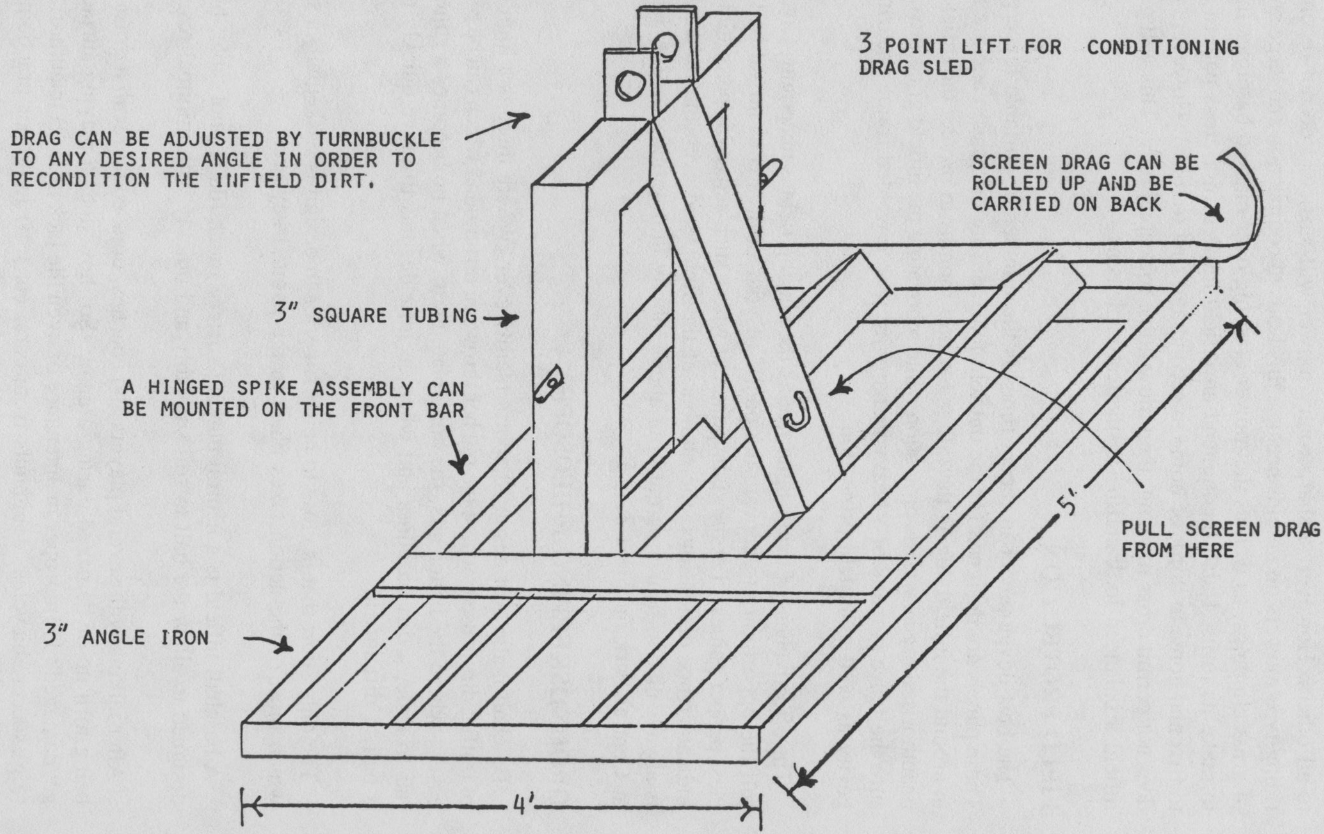
The only sport that is close to being superior in design is basketball, a sport in which most of the action takes place in the painted key area.

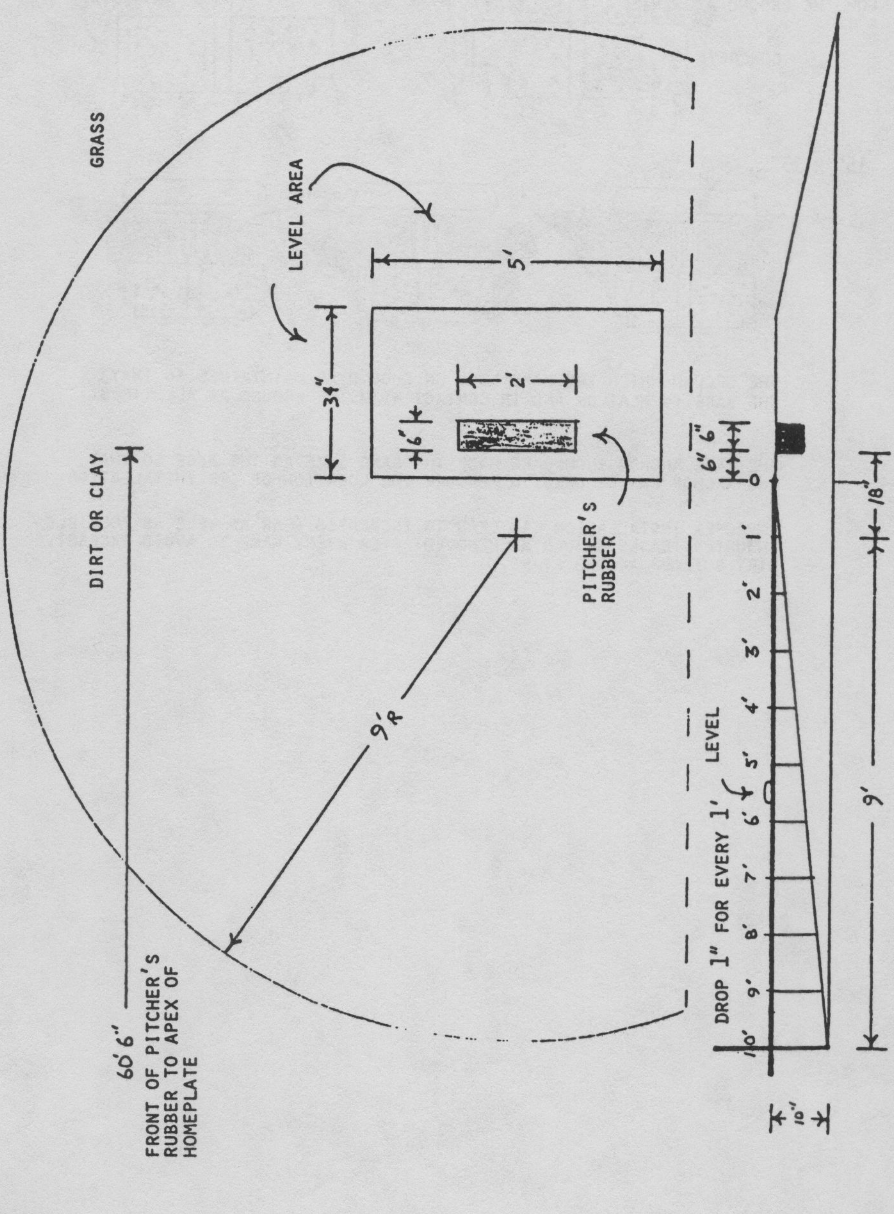
A baseball infield is a neutral playing surface much like a pool table; both are designed to allow the ball to roll smoothly and quickly with minimal resistance.

After talking with several players and coaches, none could recall a grass infield being torn up or damaged during a game. So, how does a playing surface ever get damaged? 1) Improper maintenance or even the lack of it; 2) unauthorized use (e.g. soccer, bicycles, doughnuts from cars, etc.); 3) improper practicing (e.g. sprints or infield, playing catch and excessive batting practice at the same location).

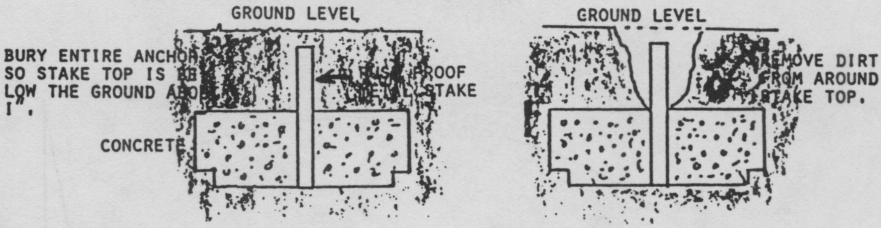
The best all around baseball field is one that is consistent day in and day out.

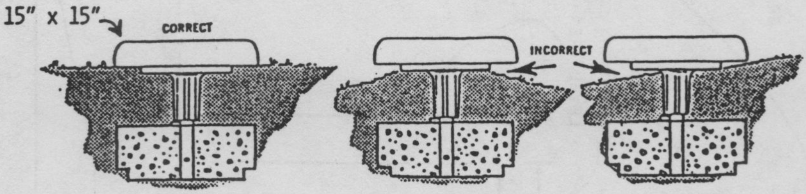
RECOMMENDED DRAG FOR SHAPING INFIELDS
BASEBALL OR SOFTBALL




GRASS
DIRT OR CLAY
LEVEL AREA
5'
34"
2'
6"
PITCHER'S RUBBER
9'R
60'6"
FRONT OF PITCHER'S RUBBER TO APEX OF HOMEPLATE
6" 6"
0 1' 2' 3' 4' 5' 6' 7' 8' 9' 10'
LEVEL
DROP 1" FOR EVERY 1'
18"
9'
10"

BASE AND BASE ANCHOR INSTALLATION





THE GROUND WHICH THE BASE LIES ON SHOULD BE MAINTAINED SO THAT THE BASE IS FLAT ON AND IN CONTACT WITH THE GROUND AT ALL TIMES.

THE BASE ANCHOR SHOULD BE MADE THE SAME SIZE AS THE BASE SO THAT THE ANCHOR CAN BE USED TO MEASURE THE LOCATION OF ITS INSTALLATION.

IMPROPER INSTALLATION CAN LEAD TO INCREASED WEAR AS WELL AS POSSIBLE INJURIES. BASES SHOULD BE REMOVED AFTER EVERY GAME TO AVOID EXCESSIVE DIRT BUILDUP AROUND STAKE.

MEASURING SPRINKLER SYSTEM APPLICATION UNIFORMITY[1]

Richard P. Regan[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
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Maintaining a high quality turfgrass during the summer months is a difficult task. Summer drought, extreme high temperatures, and increased traffic can severely damage turfgrass (Beard, 1973). Localized dry spots often occur when available soil moisture is limited especially on sand constructed golf course greens and tees. These dry spots are unsightly, reduce the overall vigor of the turfgrass, and can give rise to hydrophobic soil conditions. Recovery of the turfgrass is slow and requires weeks of intensive culture including irrigation.

Overhead or sprinkler irrigation is the most common method of irrigating turfgrass (Beard, 1973). The basic objective of sprinkler irrigation is to simulate rainfall and uniformly apply a calculated amount of water at a specific rate (Pillsbury, 1968). Absolute uniformity of applied water is never obtained in irrigation practice. The uniformity of applied water depends on sprinkler or outlet spacing, outlet type, system pressure, and wind factors. A result of poor sprinkler application uniformity is differential soil moisture replenishment and is often expressed in distinct patterns of turfgrass growth such as dry spots. In addition, when compared to good sprinkler system uniformity, a poor uniformity system will use more water to irrigate a given area (Shearer, 1969).

Turfgrass managers will compensate for poor water application uniformity by overwatering. Because dry spots develop from a lack of water, the sprinkler system is programmed to run for a greater length of time. In doing so, excessive amounts of water will be applied to other areas causing waterlogging, proneness to compaction, reduced turfgrass vigor and quality, and greater disease problems (Beard, 1973). Agricultural chemicals applied through irrigation systems will never be more evenly distributed than the water.

Davis (1969) reported that sprinkler application uniformity on golf course greens was very poor. The need for turfgrass managers to test sprinkler uniformity cannot be overemphasized. This consists of setting up a grid pattern of rain gauges or catch cans, operating the system for a period of time under normal operating conditions, and measuring the amount of water collected in each can (Pillsbury, 1968).

Catch can measurements are used to determine the uniformity of a sprinkler irrigation system. Christiansen (1942) developed a numerical index representing the system uniformity of overlapping sprinklers. This uniformity coefficient (UC) is a percentage on a scale of 0 to 100 percent (absolute uniformity). A uniformity coefficient of 80 percent is considered by many to be the minimum accepted standard. Higher uniformity coefficients are usually needed with intensively maintained and used turfgrass. Catch can measurements are also used to illustrate water distribution or patterns.

MEASURING SPRINKLER APPLICATION UNIFORMITY

Selecting the proper sample site is critical when measuring sprinkler uniformity. The objective is to select a sample area that represents both the turfgrass and irrigation system. Patterns of dry and wet turfgrass areas should be included in the sample site. Smaller areas such as golf course greens and tees or residential lawns require complete test coverage, whereas a 400 yard fairway is usually only partially covered with catch cans.

An ordinary quart oil can washed with soap and water will serve as a catch can. The surface area of the opened oil can allows it to hold approximately 200 ml of water per inch of depth. Therefore, readings to the nearest 1.0 ml equals about 0.005 inches of applied water. Wire pins attached to the side of the can or an 8-penny nail soldered to the bottom of the can helps to keep the can stationary once laid out.

Catch cans are laid out in a square grid patter that covers the sample site. As a rule of thumb, the spacing of the cans should be no greater than 10 percent of the outlet throw radius. The most common spacing used for uniformity tests is 5 feet by 5 feet. Turfgrass sprinkler outlets, when operating at the proper pressure, have a throw radius of 80 to 90 feet. Such systems can be tested by using a maximum spacing of 10 feet.

The square grid pattern is accomplished by first establishing a baseline that will serve as the origin for all catch can placements. For most studies the baseline is a straight line between sprinkler outlets on opposite edges of the sample site. Parallel and perpendicular lines to the baseline are established by using the 3,4,5 triangular method (Figure 1). Catch cans are spaced along the lines and the remaining cans are placed using line of sight. Secure catch cans to the turfgrass surface if they are in danger of tipping over.

Operate the sprinkler system under normal conditions. The operating pressure of the system affects the uniformity of sprinkler application. If wind speed is greater than 3 MPH, test results are less accurate. The effect of pressure or wind on uniformity can be determined by repeating the test during variable conditions. Operating the sprinklers for the normally programmed time yields direct information on the actual amount of water being applied during the irrigation cycle. Timed intervals of 15 minutes are useful when calculating rates per hour. Time clocks may not operate properly and checking their accuracy with a stop watch is suggested. In one test the sprinkler outlets operated for only 71 to 90 percent of the programmed time (Table 1). Observe the system as it operates and watch for plugged nozzles, improper adjustment, or damaged outlets. Dry spots in turfgrass are often caused by a malfunctioning outlet.

Collecting the data requires precise measurements. The water in each catch can is measured to the nearest 1.0 ml with a 100 ml graduated cylinder and recorded in a table or directly onto graph paper showing catch can placement to scale. If graph paper is used, the location of sprinkler outlets and turfgrass boundaries should be included for future reference.

CALCULATING CHRISTIANSEN'S UNIFORMITY - UC

Christiansen's uniformity coefficient (UC) is the most commonly used statistical method for evaluating sprinkler system uniformity (Morgan, 1964; Warrick, 1983). Christiansen's uniformity is defined as:

$$UC = 100\ (1.0 - \Sigma x/mn)$$

where Σx is the sum of the deviations of each observation from m, the mean value of such observations, and n is the number of observations. All deviations from the mean are positive numbers. Therefore, any negative number is changed to a positive number. For example: given a mean of 35 ml, an observation of 31 ml would have a deviation of 4 ($31 - 35 = -4 = 4$).

Example:

Measurements from 15 observations were:

16, 38, 32, 22, 35, 23, 32, 35, 19, 28, 26, 34, 24, 18, 23

$UC = 100\ (2.0 - \Sigma x/mn)$

$m = 405/15 = 27$

$n = 15$

$\Sigma x = 90$

$UC = 100\ (1.0 - 90/27.15) = 77.8\%$

ILLUSTRATING SPRINKLER APPLICATION PATTERNS

The application pattern of water from a sprinkler irrigation system can be illustrated on a contour map (Figure 2). A scaled drawing on graph paper showing the placement of catch cans, sprinkler outlets, and turfgrass boundaries is used. Field data from each observation are converted from ml to inches of applied water. Measurements taken from quart oil cans are converted to inches by multiplying the total water collected in ml by 0.005. Values are recorded directly onto the scaled drawing as either inches of applied water per the irrigation cycle or rate of inches per hour.

Contour lines are used to show the gradients or patterns of applied water. Contour intervals for most turfgrass studies range from 0.1 to 0.5 inches. When completed, this drawing will show application patterns and define potential problem areas related to dry spots or overwatering. A bar graph is also used to illustrate uniformity of applied water (Figure 3).

INTERPRETING THE RESULTS

Maintenance of turfgrass is more difficult when the application uniformity of the sprinkler irrigation system is poor. Dry spots that result from low water application are the most obvious symptom that turfgrass managers encounter. Waterlogged soils are more readily compacted reducing water infiltration, water storage capacity, and effective rooting depth.

If the uniformity coefficient (UC) is lower than 80 percent, steps should be taken to redesign or modify the sprinkler system. Changing the nozzle size is useful when making minor adjustments to the system. The operating pressure of the irrigation system was determined when it was designed. Therefore, increasing or decreasing the operating pressure to improve uniformity is useful only when the pressure has deviated from the design. Major adjustments are usually accomplished by the addition of sprinkler outlets and/or changing outlet spacing.

Sprinkler outlets that are added to the system need to be positioned carefully. In placing an outlet to correct a low water application area, another area may become overwatered. Use the application pattern map to locate a temporary outlet and test the application uniformity again before installing the outlet permanently.

Improving the application uniformity of a sprinkler system can reduce the water supply necessary to irrigate a given area. This savings in water will lower pumping and operating costs. Shearer (1969) showed that the average application required over an entire area to apply at least 1 inch of water on 90 percent of the area with a UC of 70 percent is 1.93 inches and 1.19 inches with a UC of 90 percent. The increase in UC from 70 to 90 percent would reduct the water requirement for the system by 38.3 percent. With such a savings 62.0 percent more land could be irrigated (Table 2).

Testing the sprinkler application uniformity provides the turfgrass manager with detailed information which will facilitate management decision making. Correcting irrigation systems with poor uniformity requires special considerations, especially economic aspects. Although initial costs are important, annual costs per acre compared to annual returns per acre are the best measure of the economics of an irrigation system (Israelsen, 1962). Regular sprinkler maintenance and repair are necessary components of a good irrigation program.

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Table 1. Total operating time of sprinkler outlets during sprinkler uniformity test.

Outlet No.	Actual operating time (min:sec) 1st cycle	2nd cycle	total	Percent* programmed
6	7:19	7:00	14:19	71
7	8:00	8:05	16:05	80
8	8:56	8:36	17:32	87
9	9:20	8:40	18.00	90
10	8:00	8:40	16:40	82
11	8:10	8:20	16:30	82

* Each outlet programmed for a total of 20 minutes.

Table 2. Effect of coefficient of uniformity on water requirement* (Shearer, 1969).

Uniformity coefficient	Average application required over entire area to apply at least 1 inch on 90% area	Percent water saved by improving CU from 70%	Increase in area irrigation by improving CU from 70%
90	1.19 inches	38.3	62.0%
80	1.47 inches	23.8	31.3%
70	1.93 inches	0.0	0.0

* Calculated from normal distribution curves.

FIGURE 1. Example of 3,4,5 triangular method for grid placement of catch cans

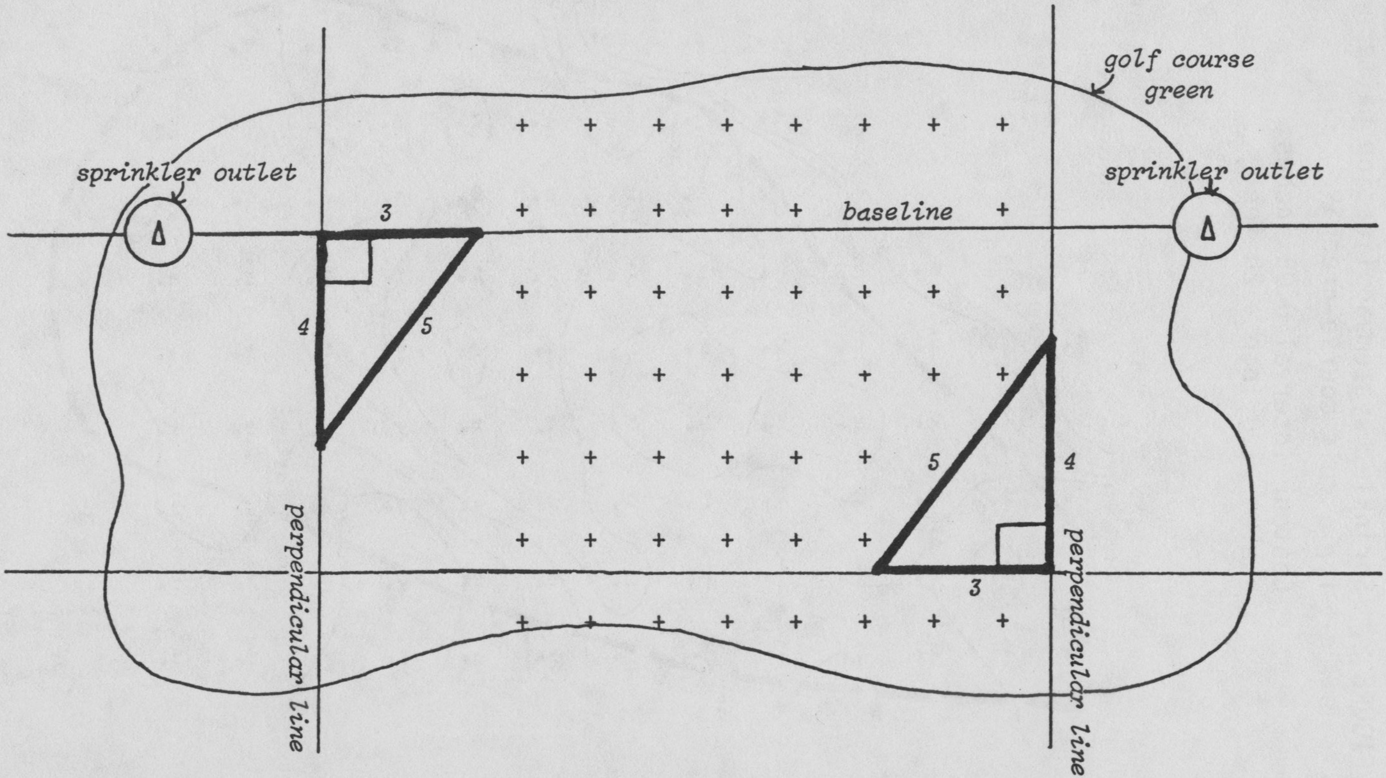


FIGURE 2. Sprinkler system application pattern for a golf course green

Contour interval 0.05 inches; scale: 1.0 inch = 20 feet

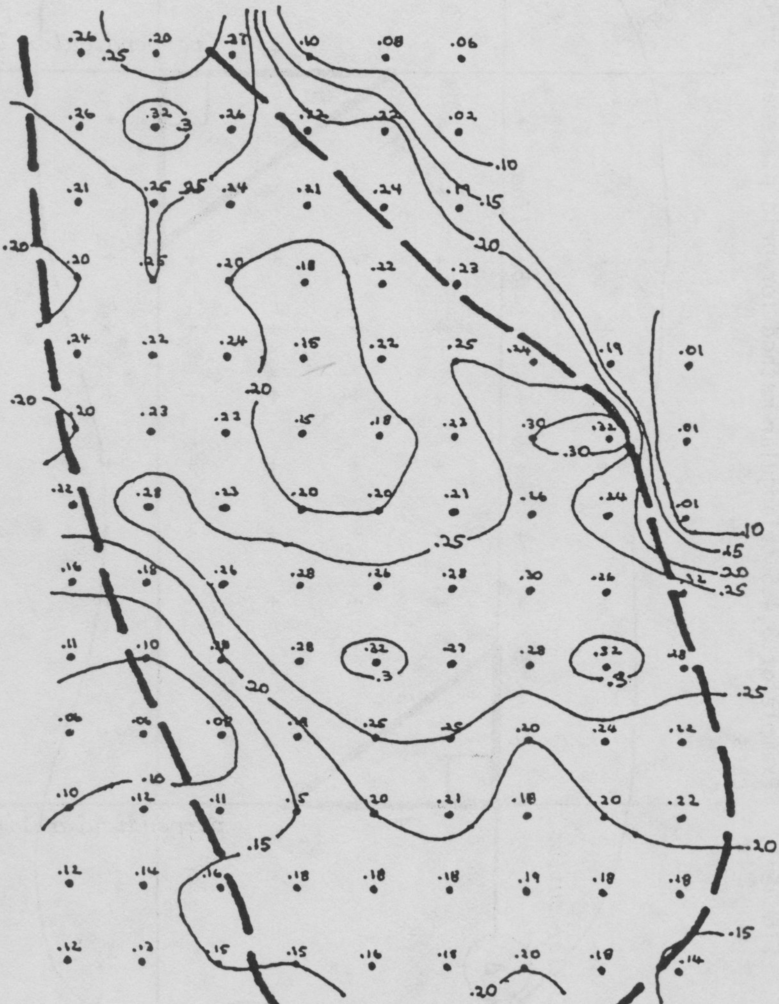
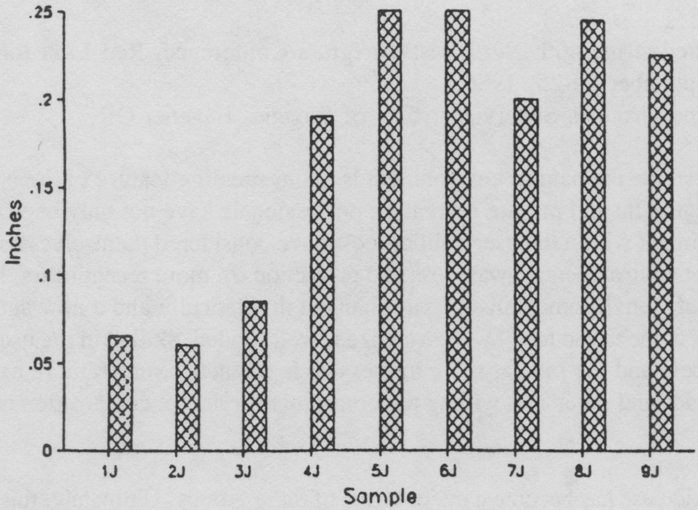


FIGURE 3: Water application pattern for a golfcourse tee cross section.



STRATEGIES FOR USING HERBICIDES IN A HOSTILE ENVIRONMENT[1]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
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Concern for the natural environment is a longstanding feature of the Northwest lifestyle. Public and private recreation professionals have not only been aware of this sentiment within the user public, most have considered themselves active supporters of environmental awareness and protection. In more recent hears, however, the fact of ''environmentalism'' has changed dramatically and a new activist element has come to the fore - well organized, well funded, skilled in the use of political process and the media, more aggressive in its tactics, much more extreme in its demands and much less willing to compromise or accept any position other than its own.

Herbicide use has become a major target of these groups. Ultimately, this includes any user of any herbicide which, in turn, includes the majority of the membership of NTA. Further, having failed to achieve sweeping bans or restrictions through scientific and regulatory channels at the federal level, they have adopted a localized strategy, focusing on a single community or even an individual organization or agency. Such tactics have been surprisingly successful and the word has been spread throughout the activist community through conferences, newsletters and national/international networks. The net effect is as simple as it is ominous—whoever you are, wherever you work. . .your organization could very well be next!

Those who answer to citizen or lay boards with limited knowledge of necessary maintenance requirements are especially vulnerable, but others cannot afford to be complacent. City or town councils may be approached with seemingly reasonable but cleverly worded resolutions (i.e. ''citizens right to know'', etc.) designed to make herbicide use so cumbersome, time-consuming and/or costly as to render it impractical in any case.

Simply meeting all federal or state/provincial requirements or knowing your LD_{50}'s will not, by itself, protect you. Your experience or college/university degree will not assure you credibility. (These can actually be twisted by clever rhetoric into negatives and used against you.) Emotional arguments and vague innuendos, properly presented to the press, can defy and withstand all reasonable and logical rebuttal. It can happen. It has already happened throughout the Northwest, perhaps somewhere or to someone you know.

It is possible, however, to defend your organization's ability to provide an acceptable service level to its clients, customers or public. Eugene is the headquarters for a number of the groups discussed above and they enjoy the support of some local politicians. Bans or unworkable restrictions on pesticide use are commonplace. In such an environment, our operations continue, free of any externally imposed restrictions. Environmental groups that once condemned us now support our program and recommend it to others. What we have done to achieve this and what we have learned doing it can help you, too, if you will apply it. That information is what I want to share with the membership of NTA.

ACT—BEFORE YOU MUST "REACT"

Among the proverbs of wise King Solomon of Israel is one that is particularly appropriate here:

> "A prudent man forseeth the evil and hideth himself;
> but the simple pass on and are punished."
>
> Prov. 22:3 & 27:12 (KJV)

It is a mistake to assume that you can continue business as usual until the activist battle reaches your community and then take action. In our experience, the only effective defense has been to establish your own environmental credentials, technical knowledge, operational responsibility and community support before-the-fact. A "fear & smear" campaign, mounted by activist extremists will attempt to portray you as unconcerned, uninformed, inept and/or attempting to deceive or hide from the community what you are doing. By addressing each of these areas in advance, you are able to nullify such an attack.

Of course, it is also essential to insure that none of these labels accurately describe you or your weed control operations. Unscrupulous, careless or lazy applicators play into the extremist's hands and damage the reputation of all grounds maintenance professionals. The fallout from a single poorly thought out or sloppily executed herbicide application can be enormous and take years to overcome. It is not an exaggeration to state that one such incident can cost you your decision-making ability/control over herbicide use or even the ability to use any herbicide at all!

Obtain a current copy of applicable regulations in your state/province concerning the proper use, storage and disposal of herbicide materials, containers, etc. Review this material (or study it if you have not done so before) and test your operations against every aspect of it. Take immediate action to correct any shortfalls. Make improvements and/or exceed the regulatory requirements where you can. Obtain a copy of the *Pacific Northwest Weed Control Handbook* (or equivalent publication) and thoroughly research the materials you are using and the weeds you use them on to insure these are in line with expert recommendations. Obtain MSDS and technical data sheets on all herbicides you use; study and file them for easy reference. You've done all that? Good, you foundation is laid and you are ready to get started.

ADOPT IPM METHODOLOGY

Integrated pest management (IPM) is a critical and, in my own opinion, essential key to persevering decision-making ability/control over weed control operations in the face of an organized anti-pesticide activist campaign. Perhaps you have the opposite impression of IPM, many professionals do. In fact, some advocates and promoters of IPM do not really understand what it is or how it works or its real relationship to the use of herbicides. Briefly, while IPM requires forethought prior to weed control action, the consideration and use where feasible of alternative, non-chemical methods and the elimination of unnecessary control actions, it retains for the manager the full range of weed control options, including herbicides, when/if necessary.

Once understood, in fact, IPM as a management strategy/tool makes excellent sense from a financial or operational standpoint, irrespective of environmental or public relations concerns. When the latter are added, it makes no sense not to adopt this methodology. You will probably discover upon examination that you already employ some aspects of the integrated approach in your current management/decision-making practices. Making the full transition will not be difficult and results in a flexible, dynamic system that can respond to the full range of horticultural variables or improvements in methods and technology.

A full discussion of IPM would require more time and space than we have today, but there is considerable printed information on the subject available and a presentation or seminar focused on it could be a future possibility. Your college/university or Extension Service contacts are another likely source of information and/or training. Whatever your source, start at once to learn the terminology and methodology of IPM and to put these into practice in your organization now. By so doing, you will begin to build a documented track record of environmental awareness, concern and responsibility.

IS THIS 'RIG' NECESSARY?

IPM methodology requires you to ask, "Is this application necessary?" Another question you should ask before making an application is the one int he heading, above—"Is this 'rig' necessary?" 'Rig', in this case, refers to motorized or PTO-driven pressure spray equipment—the classic "spray rig" commonly used in agriculture and horticulture. When using herbicides in an hostile environment, or an environment that could quickly become hostile, your rule of thumb should be *not* to use such equipment unless you cannot avoid it.

This rule can and should be extended so that you are guided by the principle of, ''the least is best''. Never use a 100 gallon tank if you need only 30 gallons of material. Use a backpack sprayer instead of motorized equipment if possible, even if you have to refill it a couple of times. Use a ''handcan'' or garden-type sprayer instead of the backpack type if it will do the job, again, even if you have to refill it once or twice. Use a wiper type applicator or granular material instead of any of the above if this will be effective. Of course, don't make any chemical application if you can do without it.

Why? Because, in the world of activist ''public information'' media campaigns, perception is as, or even more, important than fact. The more your operations can be portrayed as large scale, large volume, with high potential for exposing non-target areas through drift, ground water pollution, etc., the better the chance the public can be turned against you and convinced to write or call local officials, sign petitions or write letters to the editor of the local paper. Conversely, the more obvious the fact that you use of herbicides does not fit into those categories and the more it resembles what citizens do themselves in their own backyards or see done next door, the less likely it is that they will feel threatened by it or be frightened by distorted rhetoric.

Take some time to analyze your current methods in this light. Observe them as you think the average layperson might. Get input from board or committee members, customers or other non-professionals about their perceptions, questions or suggestions as to what you might do differently. Make changes where they are indicated and possible. Again, do this now, not after you become a target. When trouble comes, it will be much more difficult to portray your operations as a menace to public health and you will have gained supporters who can document your responsiveness to citizen concerns.

INFORMATION AND CALIBRATION—ESSENTIAL FRIENDS

You cannot know too much about the materials you use or be too precise in applying them. Keep a file of labels, MSDS (material safety data sheets) and other available information. The *PNW Weed Control Handbook* mentioned earlier, is also useful for this purpose. Whenever possible, your knowledge should go beyond this basic information, especially for frequently used or controversial herbicides. Regulatory agency, college/university or Extension Service contacts can be very helpful in obtaining this information. As you assemble and review these files, think about how to explain what they contain in language the layperson will be able to understand.

The same holds true for calibration. Make sure your staff has a thorough knowledge of all types of in-field calibration methods for any application technique you use. Be prepared to explain these in plain language. Don't forget calibration of walk-behind spreaders, handcans and hand applications of granular herbicides. Be sure you can explain how your staff does not exceed the recommended rates for these types of applications.

Remember that a common activist tactic will be to portray you as ignorant, uninformed or inept. By responding thoroughly and intelligently to inquiries in these areas, you effectively belie such arguments, increase the public's confidence in your organization and perception of safety and expose the significant lack of credibility in some of the activist's pronouncements.

AVOID NON-TARGET EXPOSURE

This is an important subject. It is equally important in discussing it to keep in mind that perception can be even more important than fact when dealing with an activist campaign. Their goal will be to generate as much fear and concern among the general public as possible; yours must be just the opposite. A cautious and balanced approach is critical, for it is in this area as much as any other that a clever duplicity is likely to be employed against you.

Demands for posting treated areas under the justification of the "public's right to know" are an increasingly consistent tactic. Careful examination of their demands will usually reveal posting requirements designed to maximize the appearance of impact or hazard from herbicide applications, far out of proportion to the reality of the situation. Regulations proposed (and defeated) for Eugene, for example, would have required posting the entire perimeter of a park if only a single weed or tree ring had been treated. Having succeeded in getting such a system in place, you could find activists, with no apparent shame, begin to take the approach, "If it isn't dangerous, why do they post all those signs?" Remember, posting implies hazard regardless of the wording so approach any such proposal with maximum skepticism.

At the same time, you should take all reasonable precautions to avoid public exposure. Timing and forethought are essential here. Don't treat the parking lot during the peak traffic hours at a pool or recreation center, avoid sportsfields during the playing season, close the trail if you must spray for poison oak. This should be a matter of common sense and yet, most of you probably know of real-life examples where it was not done.

Material choice and application technique also enter in here. The use of granular, pre-emergence herbicide materials applied during the dormant season and covered with bark mulch can dramatically reduce the need for post-emergence spray work during the spring and summer busy season. Timely treatment using wick-type applicators or hand cans while emerged weeds are few and small can further reduce real and perceived possibilities for exposure.

A word about protective clothing for applicators also is appropriate. Rest assured that the activists will be delighted if your staff looks like something out of a science fiction film while doing chemical work. The old, "It must be dangerous, look at all the protection they wear," logic can be employed again to disquiet the public at large. Of course, you should provide sufficient protective equipment to protect against any real possibility of exposure and must provide whatever is called for by official regulations.

Using small-scale, low-impact application techniques can help you once again as these normally require less protective equipment to be worn. For example, for handcan or granular material applications our staff is provided with rubber boots and rubber gloves. This actually exceeds the regulator requirement for such applications in Oregon. When mixing the concentrate material (which is the most likely point for exposure) we require goggles or a fact shield. If the operation will generate dust (which we try to avoid) or the applicator desires a respirator, it is provided. Naturally, more extensive gear is appropriate if motorized, pressure spray equipment must be used. Our staff is our most valuable resource and we protect them, but they look like the trained technicians they are, not monsters from outer space.

ACCURATE AND EFFECTIVE COMMUNICATIONS

Finally, you must prepare yourself to communicate accurately and effectively with a variety of persons who are unfamiliar with the requirements of your work and have a wide range of motives. Patience, honesty and discretion are the keys to success; written and verbal presentation skills also are of great value. If you feel weak in these areas, again, take action now to improve your skills. This is an excellent way to enhance your career and will be invaluable when you find yourself in a hostile public hearing or explaining your methods to the board.

Another essential is accurate and detailed records of all pesticide applications. Yes, I mean even spot treatments with a handcan. A computer can be invaluable for this, but thorough manual records will do. Being able to give accurate historical information enhances your "competent professional" image and should, if your IPM program is on track, demonstrate a decreasing emphasis on use of chemicals in favor of other methods making it difficult to label you a "nozzlehead".

You should make it a rule when discussing historic applications to talk in terms of the active ingredient (actual herbicide) used rather than the total volume. This is a more accurate descriptor of any real potential pollution or hazard, after all. Remember, the activist tactic is to generate maximum anxiety and concern. To accomplish this, they all-too-often resort to sensationalization or outright distortion. In such circumstances, a calm and accurate explanation of the truth is your most effective weapon.

Avoid letting herbicide use become a single-question issue. This, again, is how the activist wants it—one question, "do you use herbicide?", answer yes and you are an instant villain. Try never to discuss your use of herbicide outside of the context of your ongoing IPM program and positive history. What you don't do or no longer do is as important as the uses of chemicals you have not yet been able to eliminate—more important, really, and these additional details provide a farm more accurate picture of your operations to the one making the inquiry.

Watch out for emotionally-charged terminology. Activists love to use terms like "poison", "toxic", "hazard" or "zero risk". Their language will be carefully chosen to present as negative and frightening a picture as possible. You need to use equal care choosing the language and terminology that goes into your responses, with emphasis on more accurate, positive terms. You also should make yourself familiar with the scientific and lay definitions of the most commonly used emotional 'buzzwords' and consider how you would respond to their use. It is scientifically accurate, for example, to say that all substances are toxic and nothing is without risk. This puts an illuminating and much different light on the activist's rhetorical arguments.

Treat people who contact you with courtesy. Remember that some of them will simply be concerned and/or confused by rhetoric and will be reassured by a forthright and thorough explanation. For the more antagonistic, you will at least have provided the full story or an opportunity to hear it. Surprising things can happen. Critics can be turned into supporters and promoters of your program. You never know which call or letter may be the turning point so be consistently courteous and professional.

If possible, build a positive relationship (in advance) with responsible and rational environmental groups. There is no way to tell you for certain which groups, if any, this would be in your community. It will be necessary for you to do some research to find out. It can be obviously invaluable if your organization comes under attack from a previously unknown activist group to have the support of a better known, respected organization that can document your environmental concern and responsibility.

HAVE FAITH AND "HANG ON"

One of the most effective aspects of the localized activist strategy is the tendency it has to isolate the organization or agency attacked. It can be very lonesome when the "shooting starts". Politicians, administrators, board members, sometimes even peers may try to distance themselves from the trouble. At such times it is essential that you have done your homework and prepared yourself and your staff that your confidence in your IPM methods and ability to answer fallacious charges is unshakeable. It can be a long and lonely struggle, but it is most definitely possible to win.

I have believed for some time now that the activists will eventually defeat themselves. Distortion, duplicity, empty emotional rhetoric, and other questionable tactics will inevitably invite the contempt they deserve and lead to a loss of credibility and influence. My fears are that, in their demise, real damage also will be done to worthy environmental causes and that, before that day arrives they will have done irreparable damage to the grounds maintenance industry. I would personally regret either of these eventualities.

I have now spoken to you for something less than an hour. Additional hours were spent in preparation, in writing a Proceedings paper and in travel to Pasco for these meetings. I did not seek the role of spokesman on this less-than-pleasant subject. The battle came to me unbidden and for almost seven years has been a part of my life only because, when capitulation would have been the most convenient course, I chose to defend my staff and my operations. The preparation, travel and presentation will all have been worthwhile if I learn at future conferences that the battle came, unbidden, to some of you as well but you had listened; you were ready; you, too, resisted. . .and you won.

FINE FESCUES—WHAT IS THEIR PLACE IN PARKS AND SCHOOL GROUNDS[1]

Dr. William A. Meyer[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Turf-Seed, Inc., Hubbard, OR.

The chewings, slender creeping, creeping or spreading, hard and sheeps fescues are the predominant species included in the group referred to as fine fescues. All of the improved varieties of fine fescues have the ability to form a very fine, dense turf and to maintain good density at low fertility. They will tolerate infertile, droughty and acidic soil conditions. They are best known for their ability to persist in shade and in competition with tree roots. They will not tolerate wet soils or perform well in open sun under high fertility and irrigation because of damage on most varieties from leaf spot caused by *Bipolaris sorokiniana* and *Drechslera poa*.

The fine fescues are well adapted to many park and school ground areas. They can persist under moderate foot traffic but will not do well in areas continually used for intense athletic activities. Many school and park systems are under tight budget constraints. The ability of fine fescues to persist under reduced fertility and irrigation and their slower rate of vertical growth compared to other cool-season turfgrasses results in lower maintenance costs.

The fine fescues are widely used in mixtures with Kentucky bluegrasses and turf-type perennial ryegrasses. The five important species of fine fescue have different growth characteristics, levels of disease resistance and competitive abilities in mixtures. The following discussion will describe some of the merits of the important fine fescue species.

CHEWINGS FESCUE

This is a very low growing, fine bladed species, producing only basal tillers and no rhizomes. They perform well in the cooler areas of the Northwest and will tolerate close mowing (down to 1/4 inch) better than other fine fescues. Jamestown, Banner, Shadow and Victory are improved cultivars with better heat tolerance and leaf spot resistance than the other varieties, Cascade and Highlight. The improved cultivars have performed well in shade and in competition with tree roots. Powdery mildew can be a problem in shaded areas. The variety, Shadow, was selected for improved resistance to this disease. All of the improved varieties have better tolerance to red thread disease than the creeping fescues, but improvements are still needed.

Chewings fescues have very good seedling vigor. They are very dense, aggressive sod formers, which can be a disadvantage when they are used in mixtures with Kentucky bluegrass by being too competitive and rapid thatch accumulation. They combine better in mixtures with turftype perennial ryegrass, which is more competitive, and help to keep a balance of species. Because of their competitive ability, they should be used at lower percentages than creeping fescues in mixtures.

SLENDER CREEPING FESCUE

Dawson is the most popular example of this group. It forms short, thin rhizomes and looks similar to chewings fescue. Dawson is susceptible to red thread but more resistant to leaf spot than other fine fescues. It has good seedling vigor but has been a less consistent seed yielder than the better chewings fescues. Dawson has an establishment rate similar to the better chewings fescues.

CREEPING OR SPREADING FESCUES

These fescues have wider leaves than other fine fescues and produce extensive rhizomes. They will not tolerate close mowing (best at 1-1/4 inches and higher), but have very good seedling vigor and seed production. Fortress, Ruby and Ensylva are creeping types with less leaf spot and red thread resistance than the best fine fescues. Flyer is a new creeping fescue variety with improvements in heat and disease tolerance. These cultivars have a more open growth habit and can recover from moderate drought better than other fine fescues because of their regrowth from the underground rhizomes. They are used widely in mixtures with Kentucky bluegrass and perennial ryegrass. They have good shade tolerance and can be used effectively for hill sides where mowing is difficult.

HARD FESCUES

Biljart (C-26), Reliant, Spartan, Scaldis, Aurora and Waldina are some of the top hard fescues available. They are similar in appearance to the chewings fescues but they have a somewhat duller (less shiny) leaf appearance, a slower rate of vertical growth and improved heat tolerance. They have shown moderate resistance to powdery mildew, good resistance to leaf spot and, by far, the best resistance to red thread when compared to the chewings and creeping fescues. Their rate of establishment is slower than the other fine fescues but more rapid than Kentucky bluegrass. They have a seed count per pound almost double that of chewings and creeping fescue. The limited commercial availability of hard fescues has been caused by their lack of field burning tolerance in production fields, which limits the productive life of fields to 2 or 3 years. Breeding work has been done to select clones for use in varieties that can sustain good seed head formation over a longer period of time in absence of field burning. Aurora is a new variety that has been developed with improved seed production.

The improved varieties of hard fescues have been topping most regional and national tests when they are tested in comparison to other fine fescues. This has resulted from their better disease resistance and heat tolerance.

SHEEPS FESCUE

Sheeps fescue has had a minor usage as a turfgrass. This has mainly been due to the limited availability of commercial varieties. The variety, Covar, and the common sheeps fescue imported from Europe have not performed well in turf. This species can be found in many shaded areas and under very poor soil conditions. Many of the common strains have a wiry-grainy appearance and a blue-gray green color. The variety, Bighorn, is a new sheeps fescue with improved turf-forming ability. It has shown better establishment characteristics than hard fescues, especially under wet conditions and also improved leaf spot and red thread resistance.

MIXTURES WITH FINE FESCUES

From the above discussion, it is apparent that the different fine fescue species do vary in their growth characteristics and can compliment each others. There is merit in using creeping or chewings fescues in combination with the hard fescue in mixtures because of their better establishment rate.

The presence of hard fescues in mixtures can enhance the red thread resistance of mixtures with other fine fescues and perennial ryegrass. The presence of the rhizomatous creeping fescues give improved recuperative potential to mixtures when recovery from injury such as drought is needed. When fine fescues are desired in a mixture, a combination of species that compliment each other should result in the highest quality, long lasting turf.

SUCCESSFUL LOW BUDGET RENOVATION OF ATHLETIC FIELDS[1]

Dennis Johnson[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

[2] Director of Grounds Maintenance, Southern Oregon State College, Ashland, OR.

All football fields are typical in that they all take a heavy beating, especially down the center zone where the action takes place. Southern Oregon State College's field was typical, except that we carried the ghost of those fall activities throughout the remaining seasons. Additional topdressings in preparation for the upcoming season became no more than a veneer of sand that soon revealed a field in need, but in need of what?

That was the question I was confronted with and soon had the opportunity to present to the Athletic Board. Our initial meeting was typical too, with the rehashing of the same old observations and band-aid remedies, which for the most part, fell upon deaf ears—with the exception of a casual remark that the Grounds Department "was beyond maintenance remedies". This comment hit home, and after a moment's silence, the door holding back the nightmare of all athletic departments was opened with their own question, "What would you recommend?", and the door stop, "With this much money?"

LOW BUDGETS

The budget limit for renovating the field was $10,000, a low budget in our estimation, but nevertheless one that had to solve many problems. Our program would have to be exact; the means allowed no room for error, and the only questions remaining were, could we do it and what would be the end result?

CRITICAL PATH

The bottom line was set aside for the time being, and we began an intensive inventory to determine what we had before we set a goal for where we were going. The soils and field conditions were evaluated followed by the grasses, then the irrigation and drainage.

Soil tests gave much needed information about the chemical condition of the field as well as the soil classification to determine its water permeability rate and the fertilization requirements.

The inventory disclosed many problems: heavy compaction, 4 inches or more of thatch, high and low areas along with low soil permeability. From this base of data and the limiting scope of the budget, we sketched out a plan.

The problems were identified and listed together with a corresponding correction; this information was placed along a line of time-for-completion. Each sequence was broken down into costs for labor and material. The finished schedule would be our critical path method for renovation; and if our estimates were correct, we would be within the budget limit.

TIME AND COOPERATION

The critical path schedule allowed five weeks to accomplish the project, but a full season lay-over was desirable to establish a quality system under the care of a good maintenance program. This information was presented to the Athletic Board with the emphasis that the extra time would enable the field to hold up against the intensive use ahead.

We were fortunate—the construction of the new stadium had been delayed beyond the opening date of the scheduled fall football season. This opportunity, along with a generous amount of understanding and the desire to have the best field they could get, prompted the Board to schedule the fall season on another field. This type of cooperation and extended time interval was a key factor to the success of the renovation project.

RENOVATION

The first week began with an herbicide application to eliminate broadleaf weeds. This was followed with a reel mowing and scalping with progressive lowering to reduce the 3-inch-plus of thatch. The thatching carried into the second week where we were able to use the flail mower. The turf was swept after each passover, then mowed again until we reached the desired soil level.

The field was aerated in the third week with a 4-way system. The plus were swept from the surface, and we began filling the low areas with a soil-sand blend. With the low areas corrected, a complete topdressing of plaster sand was applied over the entire field and matted in.

The fourth week began with overseeding a 3-way blend of improved ryegrasses at 10 lb per 1000 ft^2. A topdressing of plaster sand was then placed over the seed and the field was matted again. Afterwards, a coverage of Parex starter fertilizer, 14-19-19, was applied.

Irrigation began in the fifth week through a quick coupler system. The new growth was mowed two to three times a week based upon its growth rate rather than a fixed schedule. The turf was cut at 3/4 to one inch height, at the request of the Athletic Department. After each mowing, the clippings were removed with a turf-vac.

Maintenance was carried throughout the fall season. In the spring, an application of Parex 28-3-5 fertilizer, together with sulfur, was applied. Then in the summer and fall we switched the fertilizer to 24-4-12, and sulfur was again applied in the fall and spring at a rate of 1 lb S per 1000 ft^2.

In March, an application of Ronstar Pre-emergence herbicide was applied to the field to control crabgrass. In May, 2,4-D and MCPP were applied to control broadleaf weeds.

BENEFITS

The 1983 football season, as well as those that followed, have shown a marked decline in knee and ankle injuries. This benefit alone was worth the cost of renovation; but there are also other benefits worth mentioning. Maintenance costs have been reduced, and rather than a crew to keep the field in shape, we have a single employee who is specifically in charge of caring for the field. More important, this person is ''in touch'' with everything that takes place on the field, and with this type of control, emerging problems are cut-off in advance.

LOOKING BACK, LOOKING AHEAD

To summarize Low Budget Renovation, I must look back on our problems to a time when a ''once'' good field slowly evolved into a problem field. If the success we are enjoying now is to be maintained, we must look ahead with a constant and diligent program of maintenance. In conclusion, the renovation project did come in under the $10,000 limit by $1,600.

SELECTION AND EARLY MAINTENANCE OF TREES FOR STREETS, PARKS AND GROUNDS[1]

Pat Elder[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

[2] Park Horticulturist, Seattle Department of Parks and Recreation, Seattle, WA.

I do not presume to argue the value of trees in the city. We have surpassed that point and are here to discuss the mechanics of selecting those trees that will survive in the urban environment. Surviving to the point of not merely staying alive, but growing and remaining healthy into maturity and finally replacement. Outlined below are those factors which must be understood and accommodated if an individual or agency is going to develop a successful municipal tree program.

TREE SELECTION:

1. Political Factors:

   A. Life Cycle Costs—Budget and Funding Sources

   B. Constituencies—Tree Lover vs Tree Hater

   C. Views, Signs, Greenbelt, Utilities

   D. Vandals and Terrorists

   E. City Ordinances and Enforcement Policies

2. Design Characteristics of Trees

   A. Form—Achieved or Natural

   B. Texture—Determined by leaves, branches, twigs

   C. Fruit/Flowers

   D. Color—Spring/Fall

   E. Time and Space—Immediate vs Eventual Impact

   F. Shade/Shadow

3. Horticultural Characteristics of Trees:

   A. Growth Habit—Form, Texture, Fruit, Flowers, Thorns, Branching Habits, EMH

   B. Growth Rate—Fast, Moderate, Slow, Long or Short-Lived

   C. Root System—Shallow, Deep, Invasive

   D. Moisture Requirements

   E. Soil Requirements

   F. Susceptibility to insects/disease

   G. Exposure—Sun, Wind, Salt, Snow, Ice

   H. Toxic or Noxious Parts

   I. Environmental Tolerances—Pollutant, Reflected Heat

   J. Deciduous vs Evergreen

4. Economical Factors

   A. Availability: Quantity, Quality, Location

   B. Condition: Size, BB, BR, Box, Container

   C. Cost: $$$

5. Maintenance Factors:

   A.Funding—Static, Fluctuating, Increasing/Decreasing

   B. Labor Force—Amount, Quality, Quantity, Knowledge/Experience

   C. User Population—Help/Hinder

   D. Maintenance Practices:

      1. Initial installation

      2. Tree pits

3. Watering

4. Fertilization

5. Staking

6. Pruning

7. Spraying

8. Leaf Gathering

9. Removal/Replacement/Disposal

10. Maintenance Program—Routine, Demand

In this presentation I have given much attention to the selection of trees and relatively little attention to early maintenance. I have done this realizing that nowhere is the adage "an ounce of prevention is worth a pound of cure" as true as in the maintenance of trees. The improper selection of trees can bankrupt a maintenance budget and destine a tree program to failure.

Simply stated, trees poorly selected and improperly sited or installed will require greater maintenance efforts throughout their entire life cycle than trees which are properly selected and planted. If adequate effort is put into the tree selection process, the maintenance program can be dramatically reduced. There is, however, no substitute for early maintenance. Newly planted trees must be properly watered in order to become established. They must be pruned to set the structure which the mature tree will assume. There must be continued weed removal to eliminate competition for moisture and nutrients and, perhaps most importantly, they must be protected from mechanical damage. Trees are an investment in our cities and the quality of life that we enjoy there; but as with any investment, wisdom and sound judgment must prevail if we are to reap the dividend which we envision.

Following is a list of several select references which should provide answers to many of the questions encountered regarding basic tree selection and maintenance. My apologies if I have failed to include your favorite resource.

Arnold, Henry F. 1980. Trees in urban design. Van Nostrand Reinhold Co.

Dirr, Michael A. 1977. Manual of woody landscape plants: Their identification, ornamental characteristics, culture, propagation and uses. Stipes Publishing Co.

Harris, Richard W. 1973. Arboriculture—Care of trees, shrubs and vines in the landscape. Prentice-Hall, Inc.

Johnson, Hugh. 1984. Encyclopedia of trees. Gallery Books.

Prione, Pascal Pompey. 1972. Tree maintenance. 5th Edition, Oxford University Press.

Shigo, Alex L. 1986. A new tree biology. Shigo & Trees, Associates.

Shigo, Alex L. 1986. A new tree biology dictionary. Shigo & Trees, Associates.

Sunset. 1979. New western garden book. Lane Publishing Co.

PAMPHLETS:

Seattle's City Forest, Seattle Engineering Department.

Tree decay: An expanded concept. 1979. U.S.D.A. Bulletin No. 419.

Guide for establishing values of trees and other plants. 6th edition, International Society of Arboriculture.

STANDARD SPECIFICATIONS FOR LANDSCAPING

GENERAL

Landscape Contractor—Must be experienced in landscape work of the highest professional quality and have equipment and personnel adequate to perform the work specified.

Underground Utilities—All existing known utilities will be shown on the drawings. The landscape contractor shall be responsible for the protection of said utilities and shall repair any damage to same.

Protection—The contractor shall take any necessary precautions to protect work in progress, protect adjoining property, and be responsible for protection from bodily injury due to construction operations.

Permits, Codes and Regulations—The contract documents will have been approved by the Building Department, therefore the contractor shall obtain all necessary permits prior to the preconstruction conference and commencement of the work. All work shall comply with applicable codes and regulations.

Workmanship—Workmanship shall be equal to the best accepted trade practices.

SITE GRADING

Rough Grading—It shall be the contractor's responsibility to do all cutting and filling necessary to provide a proper subgrade, removing from the site excess and undesirable material. Any additional fill material required will be furnished by the Contractor from an approved source.

Finish Grading—The landscape contractor shall be responsible for bringing lawn and planted areas to finished grade. The depths of planting soils will vary with existing conditions, four (4) inches being considered a minimum for ground cover, seeded, and sodded areas.

PLANT MATERIALS

General—The contract will be based on the bidder having verified, prior to bidding, that all plants of the size, species, variety and quality noted and specified can be furnished.

Quality—All plants shall be nursery grown, of normal habit of growth, healthy, vigorous and free of disease, insect eggs and larvae. Plants shall not be pruned prior to delivery. Grading of plant material shall be in accordance with the code of standards of the American Association of Nurserymen. Nomenclature shall conform with Standardized Plant Names, second edition, 1942. Names not present in this listing shall conform to accepted nomenclature in the nursery trade. Plant materials not meeting above quality by Parks Engineer shall be promptly replaced by the contractor at his own expense.

Plant Size—Plant sizes shall be at least equal to the minimum size specified. Any undergrade plants shall be removed and replaced prior to provisional acceptance.

Container Stock—Shall have been grown in its delivery container for not less than six (6) months, but for not more than two (2) years. Any rootbound material will not be accepted. Container stock shall not be handled by trunks, stems or tops.

Anti-Desiccant—"Wilt-pruf" or any approved anti-desiccant shall be applied to all plant material planted later than June 1 or up to October 1. Apply in accordance with manufacturer's recommendation.

SOIL PREPARATION

Additive materials for preparation and installation of turf areas or mulching of planted areas shall be in accordance with the Department of Parks and Recreation Standard Specifications as follows:

1. Fertilizer 10-20-20
2. Fertilizer 6-2-4
3. Fertilizer 6-10-8
4. Lime, Dolomite
5. Manure and Sawdust (steerco)
6. Bark, Mulch
7. Lawn Grass Seed Mix
8. Playfield Grass Seed Mix
9. White Dutch Clover Seed
10. Sod

Soils to be furnished by Contractor—The following soil types will be furnished by the Contractor from a source of supply that has been approved by the Department of Parks and Recreation. Material from other than approved sources must be submitted to the Department of Parks and Recreation for testing and approval prior to use on any job. The cost for testing must be born by the Contractor.

Sod shall be layered over the prepared and moistened soil, lightly raking the soil ahead of each sod strip and laying sod with all joints tightly butted and staggered. Sod placed on slopes shall be laid at right angles to the natural flow of water. For steep slopes sod shall be pegged to prevent slippage. As soon as possible the placed sod shall be watered.

Turf Maintenance—Seeded and sodded areas shall be kept moist until well established. Protection and maintenance shall continue through the first mowing, or until the entire landscape project is provisionally accepted. After the first mowing, the turf shall be fertilized with 6-2-4 at the rate of 30 lb per 1000 ft^2.

Clover Seeding—Areas indicated for seeding with clover will, unless otherwise noted, be cleaned of extraneous material and scarified to a depth of 4 inches. After scarifying the entire area shall be raked, removing any extraneous material exposed during scarifying.

Fertilize with 6-10-8 at the rate of 40 lb per 1000 ft^2 before broadcast seeding or hydroseeding at the rate of one (1) lb of seed per 5000 ft^2.

GROUND COVERS

Ground cover areas shall be cleaned of all extraneous material before and after cultivating to six (6) inch depth and adding four (4) inches of planting soil, 2-way mix. Ground cover shall be installed according to the Department of Parks and Recreation Standard Detail No. 0284.54. Set plants to grade and backfill with planting soil. After plantings are completed, the beds shall be covered with two (2) inches of mulch, manure, saw-dust mix, No. 0281.09.

TREES AND SHRUBS

Trees—Tree pits shall be excavated to a diameter one foot greater than the spread of the roots. Depth of pit to allow for cushion of 1′ x 2′ x 6″ root filled humus cut from forest floor. This is to promote inoculant for mycorrhizal fungi. The pit must have drainage, either vertically or laterally or as shown on the contract plans. After setting to proper grade and backfilling with planting soil, the planting pocket shall be water puddled to eliminate any voids. Bring backfill to finished grade, forming saucer for watering, mulch with two (2) inches of bark as shown in Department of Parks and Recreation Standard Detail Nos. 0284.51 and 0284.52.

Tree Staking Materials—Deciduous trees under 2-1/2 inches caliper shall be as shown in Standard Detail No. 0284.51. Deciduous trees over 2-1/2 inches caliper shall be metal staked with two (2) 1/4 x 2″ L's 8 feet long, driven to solid bearing, then tied with 18 ga. "Tie" wire protected with section of black rubber hose. If stakes are not individually solid, a 1 x 3″ clean shall be wired to stakes or stiffener per Standard Detail No. 0284.51. Evergreen trees under 2 inches calipers shall be staked, using a 2 x 2 x 10′ Douglas-fir stake driven diagonally into the prevailing wind. Secure trunk of tree with wraps of baling twine over a burlap pad as per STandard Detail No. 0284.52. Evergreen trees over 2 inches caliper shall be staked as shown in Standard Detail No. 0284.52.

Shrubs—After outlining shrub bed and establishing plant spacing, excavate plant pits to a diameter six (6) inches greater than the spread of the roots, being sure that the pit has adequate drainage. Set plant on planting soil cushion, roll back burlap on B & B material, backfill with 2-way mix to finish grade and water puddle. Smooth surface of planting bed and mulch with two (2) inches of mulch, manure and sawdust (No. 0281.09) as shown in Department of Parks and Recreation Standard Detail No. 0284.53.

MAINTENANCE

The turf and planted areas shall be maintained by the landscape contractor until all of the project is provisionally accepted by the owner.

Maintenance of the planted areas shall include watering, protection from insects or disease, weeding, and pruning, as well as replacement of any plants which appear to be in distress. Tree stakes shall be kept secure at all times. Replacements shall be promptly planted after notification.

Maintenance of turf areas shall include protection, watering, mowing and edging. All grass clippings shall be removed.

INSPECTION AND PROVISIONAL ACCEPTANCE

After completion of all landscape work, including second fertilization of turf areas, the contractor shall request the Park Engineer for a final inspection. Upon completion of any punch list, provisional acceptance of the work will be certified in writing by the Park Engineer.

GUARANTEE

Two percent (2%) of the landscape costs will be withheld for a period of one year after provisional acceptance at which time a final inspection of the work will be completed jointly by the contractor, designer, and the Park Engineer's representative. Any defective materials noted will be replaced in like kind and size, and upon completion of any replacements, final acceptance will be certified in writing by the Park Engineer.

STANDARD SPECIFICATIONS FOR FERTILIZER, TREE AND SHRUB, 6-10-8

SCOPE. This specification covers a 6-10-8 fertilizer for trees and shrubs.

REQUIREMENTS

50% of the Nitrogen shall be derived from Nitroform ''Blue Chip''.

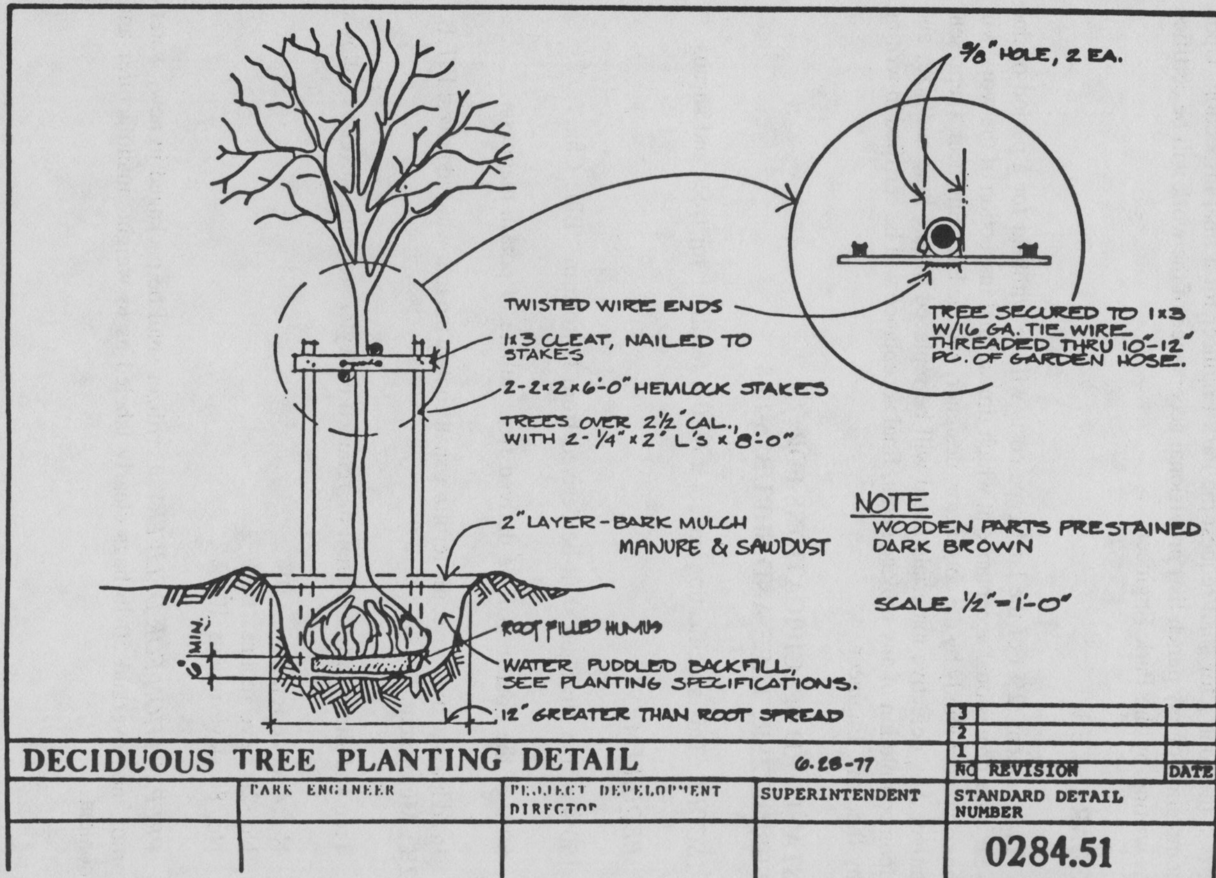
50% of the Potash shall be derived from sulfate of potash-magnesia.

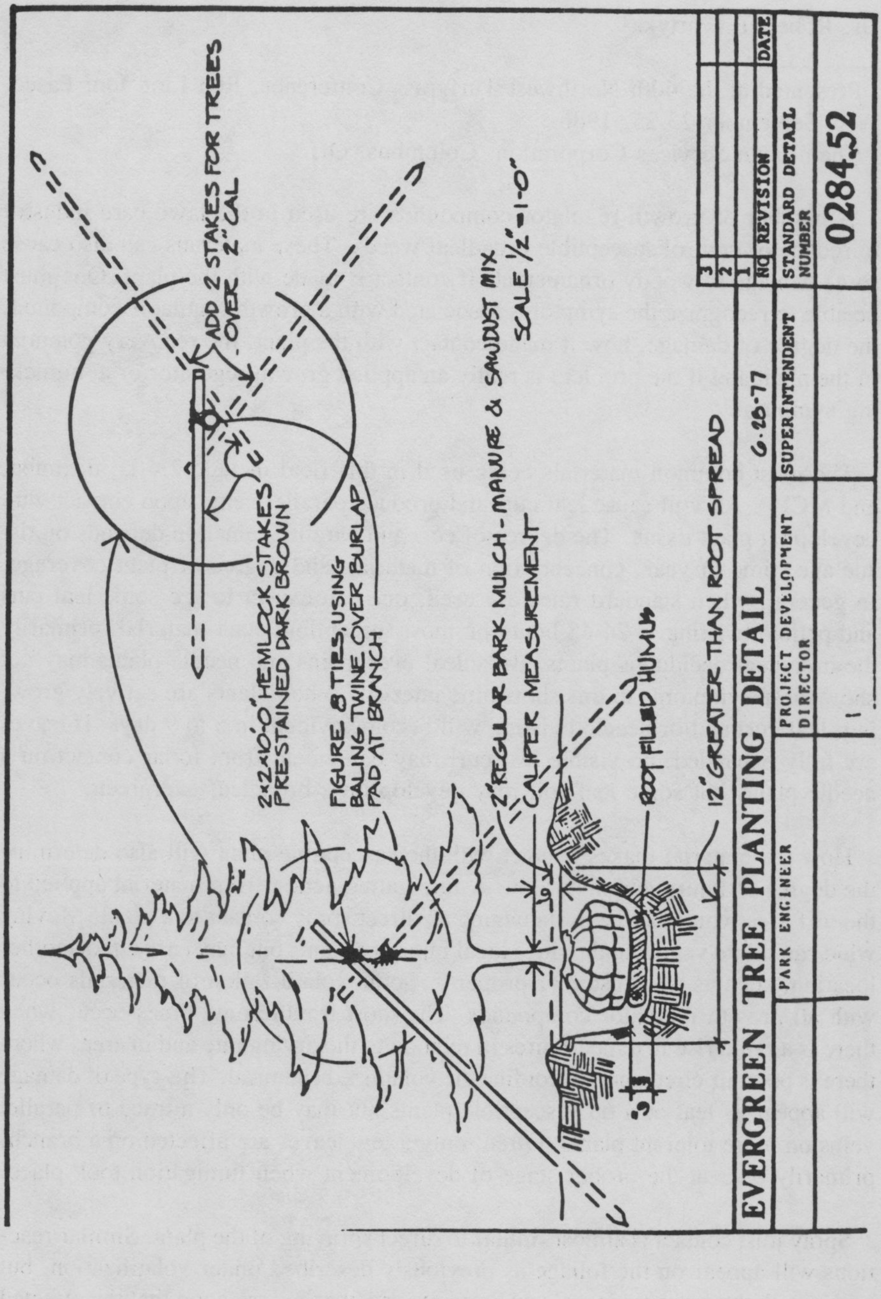
In addition to the above, the fertilizer shall contain the following additives: F.T.E., 2%; Multitracin, 0.5%.

Tree and shrub fertilizer shall be retained by Tyler standard sieves as follows:

No. 4 sieve retains	0%
No. 20 sieve retains	65%
No. 80 sieve retains	100%

PREPARATION FOR DELIVERY. Fertilizer shall be packaged in new, waterproof, non-overlaid 50 lb bags clearly labeled as to weight, manufacturer and content.


5/8" HOLE, 2 EA.
TWISTED WIRE ENDS
TREE SECURED TO 1x3 W/16 GA. TIE WIRE THREADED THRU 10"-12" PC. OF GARDEN HOSE.
1x3 CLEAT, NAILED TO STAKES
2-2x2x6'-0" HEMLOCK STAKES
TREES OVER 2½" CAL., WITH 2-1/4"x2" L'S x 8'-0"
NOTE
WOODEN PARTS PRESTAINED DARK BROWN
2" LAYER - BARK MULCH MANURE & SAWDUST
SCALE ½"=1'-0"
ROOT FILLED HUMUS
6" MIN.
WATER PUDDLED BACKFILL, SEE PLANTING SPECIFICATIONS.
12" GREATER THAN ROOT SPREAD
DECIDUOUS TREE PLANTING DETAIL
6.28-77
NO
REVISION
DATE
1
2
3
PARK ENGINEER
PROJECT DEVELOPMENT DIRECTOR
SUPERINTENDENT
STANDARD DETAIL NUMBER
0284.51



ADD 2 STAKES FOR TREES OVER 2" CAL
2x2x10'-0" HEMLOCK STAKES PRESTAINED DARK BROWN
FIGURE 8 TIES, USING BALING TWINE OVER BURLAP PAD AT BRANCH
2" REGULAR BARK MULCH - MANURE & SAWDUST MIX
CALIPER MEASUREMENT
ROOT FILLED HUMUS
12" GREATER THAN ROOT SPREAD
SCALE 1/2"=1'-0"
6"
3"
EVERGREEN TREE PLANTING DETAIL
6-28-77
PARK ENGINEER
PROJECT DEVELOPMENT DIRECTOR
SUPERINTENDENT
STANDARD DETAIL NUMBER
0284.52
NO
REVISION
DATE
3
2
1

MIMICKING SYMPTOMS— IS IT REALLY HERBICIDE DAMAGE?[1]

Dr. Robert E. Partyka[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] ChemLawn Services Corporation, Columbus, OH.

A number of growth regulator compounds are used in the lawn care industry to reduce or control susceptible broadleaf weeds. These materials can also cause some damage to woody ornamentals if contact is made with the plant. One must be able to recognize the symptoms associated with a growth regulator compound, the degree of damage, how it made contact with the plant, the recovery potential of the plant and if the problem is really an applied growth regulator or a mimicking symptom.

The most common materials being used in this field include 2,4-D, dicamba, and MCPP. All will cause leaf curl and produce parallel veins upon contact with developing plant tissue. The degree of curl and parallel veination depends on tissue age, time of year, concentration of material, and degree of plant coverage. In general, when standard rates are used, one can expect to see some leaf curl and petiole twisting in 24-48 hours on most susceptible plant material, primarily the broadleaf deciduous plants. Broadleaf evergreens and needle plants may not show these symptoms in this short time interval. When plants are actively growing, leaf curl and/or needle twisting will become evident in 5 to 9 days. If leaves are fully expanded, no visible leaf curl may be evident from foliar contact on a needle plant, but some leaf roll may develop on a broadleaf evergreen.

How the material makes contact with the susceptible plant will also determine the degree of injury and distortion. A fumigating action from material applied to the turf area would not be as damaging as direct spray contact to a plant. Moving wind can dilute vapors and reduce local injury to plants but may carry it to another location, such as non-customer property. Some volatilization of materials occur with all growth regulator compounds. The most troublesome times occur when there is a rapid rise in temperatures in relation to the drying rate and in areas where there is poor air circulation to confine the volatilized chemical. This type of damage will appear as leaf curl on susceptible plants but may be only a trace of parallel veins on more tolerant plants. Often, only a few leaves are affected on a branch, primarily ones at the proper stage of development when fumigation took place.

Spray mist contact is almost similar to direct spraying of the plant. Similar reactions will appear on the foliage as previously described under volatilization, but will usually be more noticeable and severe, and chances are good that the affected part will not grow out of the symptoms during the growing season. More material is absorbed by the plant, thus resulting in a longer symptom expression.

Root uptake of growth regulator compounds should not be a problem when label rates are followed. Most materials used are decomposed by bacterial action in warm, moist soils. The breakdown rate on dicamba is slower than other materials, but usage rates are much less likely to result in minimum concern to plants. Root uptake, if present, is generally associated with misuse of a material due to incorrect fill procedures or not understanding the nature of the compound. Repeated sprays in a tight area near plants could result in higher than normal levels in the soil. If this is then combined with a shallow rooted plant, a sandy, porous soil or a period of high rainfall shortly after application, one may experience root uptake. The symptoms of root uptake are similar to what was previously described. The main point is that the foliage continues to show distortion during the entire season and possibly into the next before it grows out. On some broadleaf deciduous plants, late season leaf curl may occur during drought stress conditions. This is often difficult to distinguish from a herbicide induced problem or one of water stress in the plant.

There have been times when symptoms appearing on plants suggest that the growth regulator compounds are held in the soil or in the roots and are expressed during periods of plant stress. Capillary soil moisture may play a role in the movement of dicamba during dry weather. Leaf curl and parallel veins are evident in the late season growth. Parallel veins often suggest that a growth regulator material suggestive of a herbicide may be involved. However, there are many normal growth regulators in plants, and weather extremes can trigger these to produce some unusual leaf growth, often a leaf curl only.

The time of year or stage of plant development is often critical as to symptom expression. Growth regulator compounds contacting woody ornamentals in the spring when rapid growth is occurring will often result in considerable distortion of leaves, stems, and petioles. Similar rates used in the latter part of the season, when rapid cell expansion has stopped, will often show minimum effects other than some petiole curl. Therefore, it is important to exercise more caution in early season applications than in late season when plant tissue is fully mature. This does not mean that one can become more careless in the latter part of the season because there are other plants, particularly flowering summer annuals and vegetables, that are still susceptible to these materials. Unfortunately, these plants are easily distorted, killed or, in the case of vegetables and fruits, flavors can be impaired to render them useless.

If herbicide damage is noted on woody ornamentals, one must determine the degree of damage and the recovery potential of the plant. Fortunately, most woody ornamentals will recover from the growth regulator materials used in the lawn care service. One could say the plants are most forgiving even though there are many distorted leaves evident during the growing season. Fertilizing to maintain a healthy plant will help if there is evidence of considerable leaf distortion. Most plants will not require any other treatments but should be kept well watered if a dry season should prevail.

One area where some damage and potential plant failure could occur would be on a recent transplant. Injury may occur if heavy rains should follow shortly after the application, and the material did not become fixed on plant tissue or soil, and the transplant was planted low in the soil so water carried the material into the rootball. A proper transplant procedure should provide for a raised ring around the rootball to confine water to the local roots and prevent surface water from entering, but this does not always happen.

Annual plants contacted by growth regulator compounds will often be damaged. Vegetables such as tomatoes may produce fruit, but will be off-flavor. The same may hold true for grapes in the home garden. Therefore, caution should be exercised around home fruit, vegetable and flower gardens when applying growth regulator compounds to lawn areas.

Recognizing what growth regulator compounds will do to plants is important in diagnosing a problem. But one has to be aware of all the other symptoms that can be produced by insects, mites, bacteria, fungi, viruses, temperature extremes and water relations in a plant. All of these will have a direct effect on normal plant growth regulator compounds in plant tissue and produce mimicking symptoms. Understanding and recognizing mimicking symptoms and their cause will help make you a true diagnostician.

Parallel veins associated with herbicides can be caused by viruses. This is common in tomato plants due to tobacco mosaic and cucumber virus. Herbicide fumigation is likely to affect all plants in an area or one side of a plant. Virus problems affect a single plant or the whole plant, seldom a portion of the plants.

Marginal leaf curl can be induced by mites which can be seen with a hand lens in the folded tissue. A first glance impression would suggest a growth hormone. There is one involved, but directed by the mite.

A trace of herbicide may result in veinal tissue being off-color. This should not be confused for a minor element deficiency in the plant, such as iron or manganese.

Severely cupped or curled leaves may be induced by leaf roller, leaf tiers or aphids. Examine the plant tissue for the presence of webs, frass, live insects or cast skins. Do not appraise the problem visually from a distance.

Slight leaf rolling can be associated with thrips or mites. Some of these are extremely small and require a hand lens to see them.

Symptoms look almost like herbicide effects. Symptoms early in the season can be due to frost or low temperatures when buds were just developing. Must relate to the stage of plant growth and temperature conditions.

Leaf discoloration at the base of a plant may be confused with frost damage. Symptoms on *Taxus* are very similar to high rates of dicamba in the soil.

Yellowing of needles on evergreens must be related to age of needles, placement on plant and time of the year. Air pollution, nutritional deficiencies, heat and drought stress or normal needle drop may confuse the issue.

Swollen and distorted leaves on some plants can be the early stages of leaf miner development. This is common on boxwood.

Leaf curl, drooping and premature coloration may relate to water stress in the plant due to low soil moisture, restricted movement in the trunk or a natural reaction in the plant.

In general, growth regulator compounds used in lawn care, produce a leaf curl, and parallel veination effect on many plants. These symptoms are often mimicked by insects, mites, viruses and environmental conditions. Seldom do these compounds cause a plant to due suddenly. Rapid death of a plant is generally due to numerous other predisposing causes that have been present for a long time and culminate at a given point in time after which all life support processes fail.

EXPERIENCES WITH SAND BASE TURF IN LITHIA PARK[1]

Kenneth J. Mickelsen[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Director, Ashland Parks and Recreation Department, Ashland, OR.

I would like to preface this presentation by saying that I am not an expert on sand base lawns. Our department has had specific experience in the installation of sand base lawns and over six years experience in the care and maintenance of sand base lawns in a park setting.

Before I talk specifically about our department's experience with sand base lawns, I need to give you a brief explanation why the department needed to select a sand base surface for certain lawn areas in a park setting. How many of you have visited Ashland and Lithia Park?

Ashland is a community of 15,000 people, and is best known for the Ashland Shakespearean Theater and Lithia Park which houses the Shakespearean Theater. Lithia Park is one of the very few parks that is on the National Register of Historic Places, mainly due to its unique history and the architectural style of the park. Lithia Park will accommodate well over three quarter million visitors a year who are intrigued by its location and beauty. Due to the tremendous number of people who utilize the park and the many community functions the park is home to, specific lawns in the park receive tremendous use and, therefore, take a tremendous beating. For almost two decades, the sixties and seventies, the park received minimal maintenance, and many of the lawn areas were nothing more than some weeds growing on top of bare decomposed granite.

When I became director in 1979, the Department embarked on a restoration project that involved restoring the lawn areas in the park. I knew from past experience, and from the amount of usage the park receives, that a traditional park lawn would not hold up to the constant wear and tear that these lawns received. I had read several articles about the new concept in athletic fields, the sand base field, and determined that this would be the best approach to re-establish lawn areas in the park. After weighing all the factors involved in re-establishing turf areas, the staff concluded specific lawns needed to be considered and treated as athletic turf areas. Therefore, a sand base surface would be a solution to being able to maintain a highly visible high quality lawn.

Before the Department jumped into the sand base concept, I contacted the Extension Department of the Oregon State University about the feasibility of sand base lawns in a park setting. I asked if it would work, and if it would be the best solution to our problem of wanting to maintain a high quality lawn under hostile conditions. They sent a representative down, a Dr. Norm Goetze, who was familiar with the concept of sand base fields. After viewing the site, he concluded that several lawn areas would be ideal for sand base lawns and, in several areas, indicated that we would be better off with Astro-turf due to the heavy usage of the lawns coupled with lack of sunlight due to the density of tree cover in some areas. He indicated that it would not be feasible to grow grass in those areas.

After Dr. Goetze's comments, we were convinced that the sand base principle would work for the lawns in Lithia Park. I continued to do additional research on sand base fields so I would be more familiar with the concept and application of sand base for a turf surface. After an entire year of researching the concept, the Department decided to implement sand base lawns in Lithia Park. Again, relaying on the expertise from the Extension office at Oregon State, and working with Dr. Goetze, we developed the plans and specifications for the installation of a sand base lawn. I need to emphasize what a tremendous resource the Extension offices of the state universities can be to a department, and the great thing is that it does not cost a great deal, if anything.

When it comes to the actual installation of the sand base, there are three critical factors which have to be considered:

1. Sand size, or particle size

2. Drainage (tile system)

3. Irrigation system

All three of these are critical, but the proper sand size/particle size probably is the most critical. There are specific guidelines available that give you the proper particle sand sizes. (See PNW Extension Bulletin No. 0240, Construction and maintenance of natural grass athletic fields.)

After we bid out the sand, we sent a sample of the sand to Oregon State to be tested to make sure it met the particle specifications of the sand we required. Before we placed the sand, we installed a tile drainage system, spacing the tile 20 feet apart, and installed the irrigation lines. I should also comment that before we placed the tile and irrigation lines, we rototilled the entire area. Next we applied 12 inches of sand over the existing soil. Then we spread fertilizer and rototilled it into the sand. For fertilizer, we used both ammonium sulfate and superphosphate. The next step was installing the irrigation heads using Toro 640's. The last step consisted of the final grading, followed by the planting of grass seed using a perennial ryegrass—the variety we use is Manhattan II.

All the literature I had read in reference to the sand base concept listed the following advantages: the turf does not become muddy; the surface does not compact; it can withstand and recover from extreme abuse. I can verify that over a six year period of use that the sand base lawns in Lithia Park have demonstrated those qualities and advantages.

This is not to say that there are no problems with sand base lawns or that the sand base lawn will solve the problem of establishing and maintaining a high quality turf that is constantly plagued with overuse. However, as I have mentioned, with six years of experience with sand base lawns in a park setting, we have learned a great deal about the management practices required to maintain a sand base park lawn in our geographic area.

First, I will tell you that we were very fortunate that after we planted the sand base lawn areas, we were able to keep the public off for an entire year. This certainly allowed us to get an excellent root growth and I believe that it is one of the major reasons we have been able to maintain a very plush lawn of high quality.

As to the maintenance program we have instituted for the sand base lawns, first is the area of fertilization. Each year we test the soil conditions, which helps us to determine the fertilization program for that year. Initially, we were using ammonium sulfate, but we soon realized that due to the rapid leach qualities of sand with a fast release fertilizer, we needed to switch to a different practice. We experimented with one whole growing season using organic fertilizers. Due to the low nitrogen content in the organic fertilizer we used, we realized that this was an expensive practice because of the amount of nitrogen the soil was receiving per application. We also noticed a slight odor for a period of time after we applied the fertilizer. Therefore, for the past three years, we have been using the following program: In the fall we have been applying a straight IBDU fertilizer (31-0-0). In either late March or early April, we apply a wax coated sulphate of ammonia fertilizer usually consisting of 15-5-7 mixture. May through August we will apply at least two applications using a sulphur coated urea consisting of a 21-3-5 mixture. Even though we have had somewhat of a set schedule for fertilization, we have discovered that it would be difficult to place the sand base lawns on a set yearly schedule. Our department horticulturist has indicated that he believes that it is important to pay attention to when lawn areas need to be fertilized, using the good old standby way of eyeballing the lawn areas.

Another critical maintenance procedure is aeration and overseeding. We aerate the sand base lawns five times a year and overseed twice a year, spring and fall, using a drill type seeder.

In reference to mowing requirements, we mow with a rotary mower twice a week and the blade has to be extremely sharp. However, we are seriously considering purchasing a reel type mower for the sand base lawns. We feel this would give us a cleaner cut. When we initially established the lawns, the recommendations we received for mowing heights were 1-1/2 inches in the fall and 2 inches in the summer. We have had to adjust that so now we are mowing 2 inches in the spring and fall and 2-1/2 inches in the summer. I cannot over-emphasize the fact that if you are using a rotary mower, the blade *must* be extremely sharp. As to watering requirements, we have determined that 2 inches is needed per week in the summer.

So far we have not witnessed a problem with thatch build-up. We do not pick up the grass clippings. We have not had to use herbicides on the sand base lawns. However, in the last year we have noticed clover is starting to be a problem.

I would like to make some general comments concerning our experience with sand base lawns: First, our experience has shown us that we have had more problems in areas where we have less than 12 inches of sand. Secondly, we have noticed that the sand base lawn performs the best and is most valuable in areas receiving full sunlight. In the shady areas, we have noticed that the sand base lawns become very spotty and are not as wear tolerant as a normal park lawn under the same circumstances. It is our experience that a sand base lawn requires more labor and is more expensive to maintain than a regular park lawn area. I want to qualify this statement by saying that if we attempted to maintain the same quality turf on a soil base surface using existing soil conditions, I don't know if a sand base lawn is actually more expensive. Also, the initial cost of the sand is very expensive.

It is our experience that a sand base lawn, with proper installation and maintenance procedures, will perform up to its expectations and will provide a lush, high quality turf area.

A PRACTICAL TOPDRESSING PROGRAM FOR PARKS[1]

Kay Kinyon[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

[2] Park Superintendent, City of Lake Oswego, Lake Oswego, OR.

I. TOP DRESSING GOALS

A. Improve soil surface porosity

B. Change to sand soil profile

C. Improve winter play (wet season)

II. EXACT ORIGIN OF PRACTICE IS OBSCURE

A. What I am doing, result of topdressing golf greens

B. Practice of sand topdressing on athletic fields highly recommended by Extension people, such as Goss and Cook

III. WHAT I AM RELATING IS MY EXPERIENCE AND OUR APPROACH IN LAKE OSWEGO, YOUR SITUATION WILL PROBABLY VARY CONSIDERABLY

A. It is not my purpose to make all of you convert to sand topdressing or the methods we use at my City

IV. METHODS I AM FAMILIAR WITH INCLUDE:

A. No. 2 shovel, manual application

B. Various greens maintenance topdressers

C. LELY rotary fertilizer spreader

D. Pickup-sized street sander

E. METER-MATIC tow behind

V. A SAND TOPDRESSING PROGRAM BY ITSELF IS NOT GOING TO SAVE YOUR TURF PROBLEMS. BEFORE EMBARKING ON AN AMBITIOUS TOPDRESSING PROGRAM, I RECOMMEND THAT YOU HAVE THE OTHER ELEMENTS OF A GOOD TURF PROGRAM IN PLACE

A. Get equipment and supplies out of the store room and on the job

B. Fertilize and soil test regularly

C. Aerate regularly

D. Control weeds and disease

E. Mow properly

F. Irrigate properly

G. Train the Maintenance Crew

H. Don't overuse your fields and avoid playing during wet supersaturated conditions

VI. WHAT TO DO, OH WHAT TO DO

A. Situations this severe will be helped by topdressing

B. Water must move from the soil surface through the soil to drain tubes, or ?

C. Sometimes you've really got to dig right in. Install trench drains and open up channels to existing drain tubes.

VII. THE OBJECT OF A HEAVY LONGTERM SAND TOPDRESSING PROGRAM

A. Convert existing field to a high sand type without taking the field out of play

B. Provide firmer conditions in rainy season play

C. Defray and reduce dollar costs of reconstructing to sand base field

D. Ultimately provide a reservoir with sand layer which will allow excess water to soak away into subsoil with lower rate of permeability.

VIII. THE ACTUAL PROCESS

A. First experiences with lone topdresser took forever

B. Loader operator quickly became:

1. Part time worker

2. Voice from heaven said:

$$\frac{\text{Average Topdressing Cycle Time}}{\text{Average Loading Time}} = \text{Number Of Topdressers Needed}$$

3. In our situation that is one front loader and two topdressers

C. How do we put the sand and the field together?

D. Equipment has to be transported to the site

1. Spreader bar necessary for lifting METER-MATICS

E. Anything can pull them

F. *Organize and spread cycle*:

1. Loader Operator is key person

2. Must have a spotting system

3. Try to use multiple access points of field margin

4. Try to locate stockpile near field

5. Try to locate stockpile on hard surface

6. Use .1 mm to 1 mm sand, most should be .5 mm

7. Topdressers should follow same spread pattern

8. Mat off between each lift

9. Avoid individual lifts that exceed 1/4 inch thick

10. Make sure no heavy sand builds up in low depressions. Hand-rake grass up if necessary

11. Allow grass to recover and soil to start to firm before next lift goes down

12. Keep track of application patterns and alternate

13. Clean up

G. How much sand?

1. 90 yd^3 will cover a football field with about 1/4 inch sand

2. 1.67 yd^3 per 1000 ft^2

3. We presently pay $7.30 per yd^3 for screened Columbia River sand

4. Typical field uses $657.00 work of sand per application

5. A typical football field takes about 4 hours with two top-dressers

6. Itemized Costs:

Labor:

1 - Crew Leader	@ $17/hr×4 hrs = $68.00
1 - Utility Worker	@ $15/hr×4 hrs = 60.00
1 - Temp. Worker	@ $ 7/hr×4 hrs = 28.00
	Total Labor 12 hrs $156.00

Equipment:

1 - Front Loader	@ $18/hr×4 hrs = $72.00
2 - Turf Trucks	@ $ 3/hr×8 hrs = 24.00
2 - Topdressers	@ $ 3/hr×8 hrs = 24.00
1 - 2-Ton Truck w/trailer	@ $12/hr×4 hrs = 48.00
2 - 1-Ton Trucks w/trailers	@ $ 3/hr×8 hrs = 24.00
	Total Equipment 32 hrs = $192.00

Materials:

90 yd^3 Screened Columbia River Sand @ \$7.30/yd = \$657.00

GRAND TOTAL \$1,005.00

H. Irrigation:

1. Sand Problems

2. Hunter

3. Toro

4. Raise Heads

IX. THE METER MATIC TOPDRESSER

A. We add our own hopper extensions to prevent overspill while loading, *DO NOT OVERFILL ORIGINAL HOPPER!!*

B. The floor belt

1. Watch adjustment and run out

2. Tear easily - avoid sand containing rocks

3. Replacement costs \$375 - 600.00+

C. The drive system

1. Is susceptible to sand-caused wear

2. Grease frequently

D. Tires, watch inflation

E. Metering gate - watch for opening creep

F. Brush - CAN BE BENT!

1. Protect from bumping and strains especially if lifting

X. THE CONS OF A HEAVY TOPDRESSING PROGRAM

A. Is reasonably priced sand available?

B. Requires specialized equipment

C. A slow process 1 to 1-1/2 inch gain per year

D. Harder to patch

E. Fertilizer requirements become more critical

F. Requires additional irrigation system maintenance

G. Open impact rotors not really compatible, TORO 640 series or the new stainless steel HUNTER are the best

H. Irrigation requirements during droughty periods is more critical

I. Some people will complain about:

1. Loose sand gets in shoulder pads

2. Slow soccer play on freshly dressed field.

PUMPS: THEIR PURPOSE AND THEIR PROBLEMS[1]

Carl H. Kuhn[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Professional Engineer, Carl H. Kuhn and Associates, Mercer Island, WA.

Whatever else may differentiate one golf course irrigation system from another, be it gadgets, widgets, Brand "X" or Brand "Y", most have the need of one or more pumping plants. Recognizing this infallible documentation and also admitting to the fact that pumps and/or pump plants fail only when the irrigation system is in the using season, it behooves all of us to become more familiar with the idiosyncrasies of these bedeviling instruments.

It is not my intention to address the maintenance of these devices as that falls into the province of Wayne Olson, the following speaker. I do intend to help you evaluate the good and bad points of each type of pump or pump plant available and to help you see these pluses and minuses from the standpoint of the superintendent, the engineer and even thru the eyes of the pump salesperson. Because most systems are of little value without the pump plant in operation, is it not ultimately important that all of us understand why there are different types of pumps, why their dollar values vary widely and why their respective reliabilities also vary greatly? So, we shall journey on a review of pumps, their purpose and their problems.

Assume you have a shopping list and a blank check with instructions from your Board of Directors to obtain a reliable and economical pump plant (and that your continuing employment rests with the success or failure of your mission). Now you really need the right answers. Ten pump salesmen might give you ten different answers to any of your questions, all of which might be essentially correct but not necessarily related to the entire spectrum of pump availability. So, let us look at what is available and how you, the superintendent, and I, the engineer, might rate these devices. Sales people can look, too. Refer to Exhibit 1 for pictorial description.

END-SUCTION CENTRIFUGAL:

(+)	(−)
Most readily available	Motor and pump built in one unit
Manufactured by many firms	More difficult to maintain
Usually most competitively priced	Limited ability to lift water
Compactly constructed	Loss of prime can be damaging
Motor can be located above ground	Somewhat noisy
Average to good efficiency	

SPLIT-CASE CENTRIFUGAL:

(+)	(−)
Manufactured by many firms	Shaft subject to misalignment
Better construction than end-suction	Limited ability to lift water
Motor and pump easily separated	Loss of prime can be damaging
Motor can be located above ground	Requires special shaft coupling
Available in high-head applications	Cost more than end suction
Usually good efficiency	Somewhat noisy

SUBMERSIBLE TURBINE

(+)	(−)
Many readily available	More expensive than centrifugals
Water lift not limited	Motor and pump tied together
Silent operation	Motor operates under water
Many manufacturers	Motor designed in small diameter
No loss of prime	Requires special sump design
Usually very good efficiency	

SHORT-COUPLED TURBINE

(+)	(−)
Motor and pump separated	Longest delivery time
Motor easily removed	Highest cost pump
Water lift not limited	Requires wet well
Semi-silent operation	
Many manufacturers	
No loss of prime	
Usually excellent efficiency	

Now that we see the general characteristics of the various types of water pumps, let us evaluate these qualities.

MAINTENANCE

There is little to choose between the split-case centrifugal and the short coupled turbine; both have motors that are readily removable without also removing the pump. Both have a quick disconnect feature. End-suction centrifugals usually require that the entire pump be removed to service either the pump or the motor. The submersible turbine requires that the entire pump be extricated from the wet-well in order to service the motor.

Since most clear-water pump problems occur in the motor, having the motor at the surface and readily removable gives the advantage to the short-coupled turbine or the split-case centrifugal.

ADAPTABILITY

The submersible turbine and the short-coupled turbine have no limits to how far they can "lift" water. In actuality, they do not lift water as is the case with a centrifugal (and which is limited by nature's vacuum constraints); turbines actually "push" water up from the supply. This is why both are very commonly used in well applications.

In all fairness to centrifugals, if they can be adapted to a water supply to provide a "flooded suction", they can be considered in the same league as their more expensive turbine counterparts.

VULNERABILITY

Any time you have your "wet end" of a pump above the water level, you must rely upon a pump-induced vacuum to bring the water up to the "wet end" (impeller) level. This is a very common approach but it also portends a serious problem on pump plants that are automated. Manual starts of centrifugals permit the observance of the pump operation; either we are pumping water or we are not pumping water. If we are not pumping water, we probably have lost prime. . . in other words, a leak in our suction pipe or debris in the suction foot valve caused the water in the impeller and suction line to leak out. Pumps do not pump air very well. Perhaps you can now get the feel for why we shudder when we are asked to use centrifugals on automatic pump systems without some form of fail-safe "loss of prime protection". There are methods available to provide this protection.

SERVICABILITY

It seems as if almost anybody aligned with pump sales can do some form of service on centrifugals. Same for small submersibles. However, the larger submersible turbines and short-coupled turbines require a more sophisticated form of maintenance. This usually means that you have less to choose from in the area of service. But, since you usually do not "shop for price" when you have a pump suddenly out of service, you can find solace in first searching the market for a reliable, responsive pump firm, have them visit your course and learn what you have in the way of pumps and pump controls. Then when the emergency arises, they can attack the problem intelligently and promptly. With turbines in particular, and even centrifugals in general, finding this firm and contracting for their future service is vitally important.

RELIABILITY

As noted previously, most problems with pumps in clean water occur in the electrical end. For this reason, any pump that has its motor above ground has a maintenance advantage. The ease with which short-coupled turbine motors can be lifted off their shaft give the maintenance edge to this pump. The same applies for a split-case centrifugal.

Knowing your water source and any problems associated with it is also important. If you pump directly out of a well, you must be aware of the quality of water and any wear this water may create. Turbines, either submersible, short-coupled or deep well, if they have problems with impellers, require a major undertaking to repair. This calls for a well derrick, removal of much pipe, column, shaft, etc., and the repair of a pump that may not be a shelf item. Reliability, then, is also a function of knowing about your problems before they happen.

WATER SOURCE

Because centrifugals ''lift'' water, they can be located next to a lake or pond and their suctions extended into the lake or pond. Even a submersible pump can be put down into the pond and the discharge piped to your system. However, the short-coupled turbine most often requires that you bring the water to the pump; this is done by construction of a wet-well . . . a continuation of the lake or pond by means of a large diameter pipe. The wet well then permits insertion of the turbine into the extended lake. The wet well is usually a very large diameter pipe, 3-4-5 or more feet in diameter. Of course, this wet well adds to the cost of the pumping plant.

Caution is advised when combining submersible turbines with a wet well. It is most important that the water circulation pattern in this marriage be carefully controlled to insure that the motor is cooled. Small diameter wet wells with intake pipes above the bottom of the pump (the motor is the bottom of the pump) require special devices to force water to circulate by the motor.

PACKAGE PUMP PLANTS

As computers have taken over the golf course irrigation market, so has the introduction of package pumping plants. More and more firms are entering this market. The major reason is the simplicity; all you have to do is connect the electrical and the pump discharge (almost). Package pump plants are fully automated, usually have a jockey pump for small flows, often have a hydro-pneumatic tank to discourage too many starts, have low water switches, high pressure reliefs, pressure control valves and all of the extra goodies such as phase protection, discharge meters, hour meters, remote sinsing devices that tell you if a pump is down, etc. You can buy them with electro-mechanical controls or micro-processor controls. There is no limit as long as you have a deep pocketbook. It is important to understand that the package pump plant is a sophisticated instrument. As a fully automated device, it is always first set up and tested by a factory expert. When the expert leaves town, the plant is operating. When the pump plant goes down, he may be 1,000 to 2,000 miles away. This is why you need to obtain the services of a qualified pump firm, one with in-depth knowledge of your particular package plant, one who has measurable pump and electrical experience and one who knows the operation of a sophisticated Cla-Val valve and its miriad of copper plumbing and micro-switches. I might add that you will not find these "package-plant experts" on a supermarket shelf; the package concept is relatively new and needs to be studied and understood by qualified local pump experts. Incidentally, there are at least three, possibly four, different manufacturers whose package plants have been installed in the Northwest...each is constructed, operated and maintained in a slightly different manner. Heed this advice...FIND YOUR MAINTENANCE FIRM NOW. Better that they learn how to repair your plant now than to wait for them to study it at some critical time during the heat of summer. And, be prepared to pay them to learn as you will pay them now or pay them later.

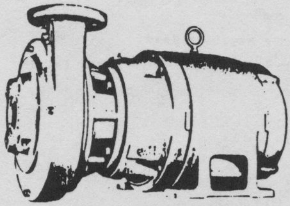
SUMMARY

Each of us is accused of having prejudices whether these prejudices apply to products or to people or to firms. This is a natural phenomenum brought about usually thru good experiences. My personal prejudice happens to apply to short-coupled turbine pumps.

So, please excuse me if I seem to be willing to spend more of your money and constantly recommend the use of short-coupled turbines. I have learned about their reliability...dry motor, wet pump, ease of maintenance and high efficiency, no loss of prime...by virtue of the fact that they have fared well in our remote overseas projects. Where maintenance must be simple, where the pump plant must be 100% reliable and where the nearest pump expert might be 8,000 miles away, the short-coupled turbine pump plant has been a rewarding venture. If it is the best plant in the remote areas of Indonesia, Malaysia or Tunisia, it must have something to offer. However, as I indicated before, if you can provide a flooded suction, you can obtain almost the same results with a much less expensive centrifugal plant.

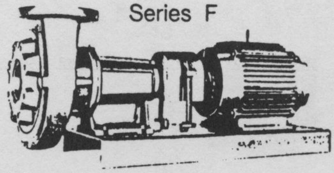
Permit me one last recommendation...build your pump plant above ground where it is easily accessible. Somehow you should be able to construct a pump plant that is aesthetically pleasing or that can be screened off. Try to avoid a below-ground, floodable, damp, hard to get a pump tomb. THINK HIGH AND DRY!

Horizontal End
Suction Pumps



Series C

Series F



Brochure B-2300

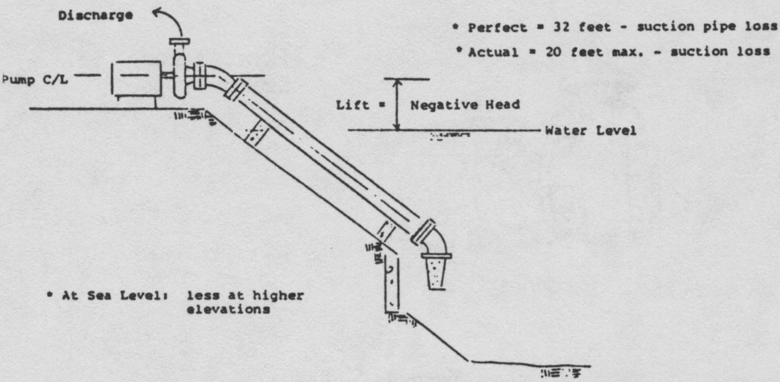
INDUSTRIAL
TURBINE PUMP

Rugged heavy duty Peerless industrial turbine pumps are available for capacities up to 100,000 gallons per minute, heads up to 1,000 psi. Corrosion resistant materials are available to resist attack by most industrially pumped liquids. Numerous configuration options allow custom-engineered construction tailored to fit the requirements of your application. Ask for brochure B-505.

DEEP WELL
SUBMERSIBLE PUMP
THE
SUBMERSIBLE

A wide selection of head-capacity ranges assures plenty of water from deep wells. Incorporates many of the same quality construction features found in the lineshaft turbine pump. Range: heads to 1000 feet, capacities to 3000 gpm, motors to 500 hp. Ask for Bulletin B-700.

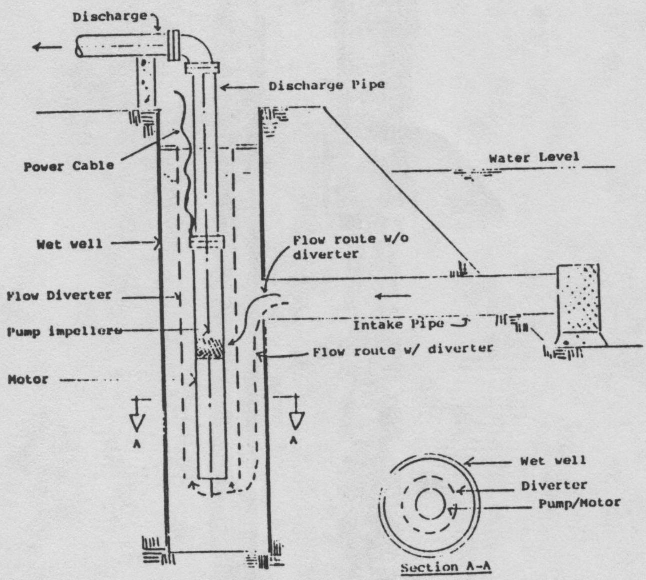
Exhibit #1



END-SUCTION OR SPLIT-CASE CENTRIFUGAL PUMP

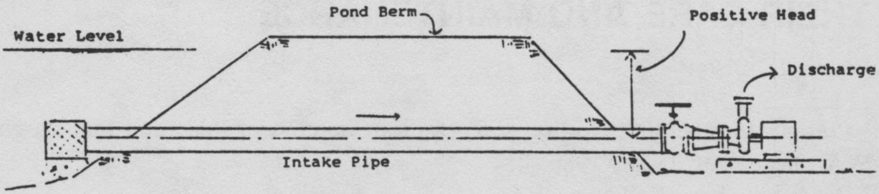
C. H. Kuhn & Associates

Exhibit #2



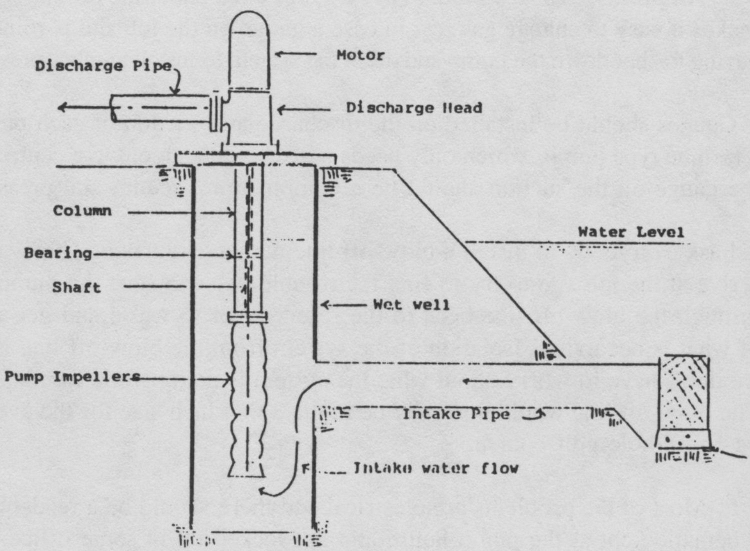
SUBMERSIBLE TURBINE

Exhibit #3



FLOODED-SUCTION CENTRIFUGAL

Exhibit #4



SHORT-COUPLED TURBINE

Exhibit #5

PUMPS—
THEIR CARE AND MAINTENANCE[1]

Wayne S. Olson[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Pumptech, Inc., Bellevue, WA.

I will start with what you can do to make a service call by a pump technician more valuable to you and save time.

1. The name plates on the pump and motor should be kept readable. This might sound a little trivial, but I have seen more than one case where original name plate data would have saved time and money.

2. Another important item is to keep a record of the original design conditions of the unit. In other words, when the pump was sold, how many gallons was it designed for and how much head was it designed for.

3. All pressure gauges should have a gauge cock under the pressure gauge. This makes it easy to change gauges, in case a gauge on the job site is ruined, without having to shut down the pump and drain the system to install another pressure gauge.

Gauges should be installed on the discharge and suction of each pump, except a turbine type pump, which only needs a discharge gauge. On a centrifugal pump the gauge on the suction should be a combination vacuum and pressure gauge.

I ask everybody to install a blow-off line with a gate valve. This way when we arrive at the job site to try to find the trouble, we can start the pump and run it through the blow-off line back to the reservoir or to waste and get a good idea of what is occurring. Isolation of the system from the blow-off line is a must so we don't have to worry about what the system is doing while running the pump. The blow-off line would normally be in the 3 to 4 inch size for the average pump on an 18-hole golf course.

5. Most of the problems are electrical and there should be a readable electrical schematic kept at the pump house and not locked up in some office. If there is an electrical schematic kept up to date in the pump house, this can save many hours by the service person. Each device should be labeled on the schematic and on the device itself. This way each device can be located quickly and its purposes known, allowing the trouble to be traced much faster than if someone has to go looking into a mass of wires trying to figure out what someone else has done. It is also a must that these schematics be kept up-to-date by anyone making changes.

Now we will discuss some specific problems and try to give you possible courses of action.

First is excessive heat. If the pump case only is hot and the motor seems to be normal temperature, you have a very definite problem. Any centrifugal pump pumping approximately 5 to 10% or more of its design capacity will have a cool case. Normally when a pump case gets hot, that means that the pump is running against shut off and not being allowed to pump enough water, and this is normally caused by someone closing the discharge valve or a plugged discharge line. When this occurs, the pump is running with no water moving through it and the energy goes to heating the water; therefore, the pump gets hot. If you determine that you are not running the pump against shutoff, check for reverse rotation. The normal centrifugal pump, while running backwards, will pump water but it will not create as much pressure as it normally does nor will it produce as much water. As a result of not being able to create the normal pressure, in many cases it will be in the static condition because it cannot create enough head to move any water. Reverse rotation sometimes occurs if you have had a motor rewound and reinstalled or if the power company has been working in your area and somehow they get the power leads reversed.

Motor heat is another subject often discussed. One thing to remember is that the T-Frame motors will run hotter to the touch than the older motors. The reason for this is that the older motors had an air gap between where you put your hand and the starter. On the new motors, you are putting hour hand directly on the case which contains the starter, thus the motor will feel a lot hotter. When we furnish a new pump to an operator who is used to an old motor he has had for years, and all of a sudden he gets a new motor and it feels warmer to the touch compared to the old motor, he gets very concerned. The temperature you feel with your hand is referred to as skin temperature. The new motors can get as hot as 150 to 160 °F and still be okay. So if you put your hand on one of the new motors and have to remove it quickly, that does not mean that motor is too hot. The best way to gauge this, of course, is to buy a magnetic thermometer which can be purchased for about $15.00, put it on the outside of the motor and actually measure the skin temperature. If it gets much over 160 to 170 °F, then there could be some concern. When you use the magnetic thermometer, I would say to put it in two or three places and take the highest reading you get for your skin temperature. Motor manufacturers tell you to measure the winding temperature with a thermometer inside the winding and, in my opinion, this is normally impractical, as it takes special instruments and knowledge. I feel the skin temperature is a good judge of what is going on. If you get excessive temperature on the motor, check the motor load with an amp meter. If the load is not over name plate amps, then usually the motor is okay. Remember, if you are drawing an overload according to an amp meter, but the skin temperature is okay, you are still overloading the motor and the problem should be corrected.

Another thing that can cause overheating of a motor is unbalanced voltage. On three-phase power you have three legs, A B and C, and you take the reading on the volt meter first from between leg A and B and then between leg A and C and then between leg B and C. These readings should be balanced; such as 472, 473 and 474, would be a good reading. If you get something like 472, 473 and 480, this unbalance can cause overheating in the motor. If the unbalanced voltage is causing problems, you can detect this by doing the following:

Using an amp meter, measure the amps on all three legs. If you notice very little unbalance on the amp reading, then the unbalanced voltage is probably not a serious problem. If it is noticed that one leg has high amps or low amps, then roll the leads, which means change three wires instead of two wires to keep the same rotation, then record where the high amps were before the leads were rolled and after the leads were rolled. If this high leg or low leg in amps follows the motor leads, then you can blame the motor. If it stays with the power, then you can generally believe it is a power problem. My experience has shown that it is generally a problem with the power. It is also my experience that to get the power company to admit this is a time-consuming process. Many instruction manuals by manufacturers, especially motor manufacturers, publish a method of rolling leads and it is a well-accepted field test.

The next thing is cavitation. This is a favorite of a lot of people in the business and a lot of servicemen. People are under the false impression that cavitation is air entry into the pump and this is not the case. Cavitation is when there is a lack of pressure inside the pump case and the water, to put it in simple terms, boils inside the pump and returns to a liquid after it gets to a high pressure area. This conversion of the liquid vapor back to a liquid causes a sudden collapsing, which is called an implosion, and it is what makes all the noise and does the damage when a pump cavitates. Three common causes of cavitation are the pump being too high above the water level, the suction pipe being partially plugged, or the pump being allowed to pump too much volute. A partially plugged suction line will cause excessive friction loss in the suction line. Cavitation has a very distinct noise. The easiest way to describe it is that it sounds like the pump is pumping gravel and the noise it makes is very distinct versus an air entry. If you discover this situation, it must be corrected immediately as when cavitation occurs to where you can hear the distinct gravel noise, the pump is not going to last long.

Another common call we get is pump loss of performance. It is not putting out what it used to do. If this is a sudden change, such as one day it pumps fine and the next day it doesn't, of course, the cause must be determined and remedied right away. This again can be caused by something lodged in the pump blocking the water path through the impeller. A lot of times it is problems on the suction side of the pump, such as plugged suction, air leak, or air entry and, the last and more embarrassing, someone turns off a valve.

Another cause of a sudden change in performance is reverse rotation, and the cause of this has been discussed. If you get a gradual loss of performance, this usually indicates the pump is wearing in the critical areas, such as the wear ring area. What I like to see done on any pump is to test it once a year with a known number of sprinklers or known volume and the pressure recorded. At the same time, take voltage amp readings so that it is known what the load on the motor is along with the voltage on all three legs. Then as time goes on, another test can be taken with the same volume as before. If there is a drop in pressure with the same volume, this indicates we are getting wear in the pump and a drop in amps can indicate the pump might be wearing. If this information is on record, it is immensely helpful in trying to track down what might be the problem.

In a short period of time, I can't cover everything about pump troubles; but I can make a general comment. Normally, the problem is a lot simpler than you might think. Look for something simple, don't make a complicated research project out of it unless necessary.

Another comment I should make is on electrical problems. You have all heard of overload heaters and how they will protect a motor. Remember that an overload heater protects the motor against overload and it takes quite a bit of time to trip the motor. It will not protect the motor against short circuits, single phasing or sudden excessive loads. I have seen more than one motor burned up, and have gone out and checked the heaters, and they were the right size and installed correctly. A good solution to this, in my opinion, is the new phase monitors, which protect you against single phasing, low voltage, phase reversal. We have been using them now for the last three or four years and I have seen them protect motors from burning out. Bear in mind that these are not 100%. I know of nothing that is 100% to protect the motor.

In closing, let me stress the importance of keeping records on your pump station. It is to your advantage and, in the long run, can save money.

CONFESSIONS OF A USGA AGRONOMIST[1]

Larry W. Gilhuly[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Western Director, USGA Green Section, Tustin, CA.

As I remember, it was a typical late August Sunday morning in 1983 when I got my first hint that I would be leaving the Pacific Northwest. While sitting in the back row of the church pews listening to the pastor speak about tough decisions one has to make in their life, I was, in a word smug. After waiting over eight years, I was going to realize my professional goal — being the golf course superintendent at Seattle Golf Club from 1984 until the day I would retire.

The very next morning as I walked into the maintenance facility, I was shook to the foundation when Milt Bauman informed me that I would be offered the USGA Green Section Western Director's position at the upcoming NTA Conference. I have to confess that this was a tough decision to leave friends and family for the wilds of Southern California. I confess that there are times when I truly miss the Pacific Northwest, but when I saw the recent thrashing of Ohio State by Washington's football team, I must admit I felt an intense glee watching the fans under their umbrellas in garbage sacks trying to keep dry in an intense rain storm!

As has been said to many of you in this room, I learned more working for Milt Bauman in three months than I learned in five years of schooling in the university system. Going to work for the USGA Green Section and Bill Bengeyfield, I can honestly admit I learned more in three months with Bill Bengeyfield than in eight years working on a golf course. The opportunity to broaden one's scope of golf course management operations is perhaps the biggest advantage of being with the USGA Green Section. After making over 500 individual visits in the past three years, I have viewed many threads that have been woven into a strong fabric of turf management operations by some of the best turf managers in the country. These managers (hopefully, this includes all of you in this room) have a set of "10 Commandments" that are followed to produce quality results. Prior to discussing my own confessions, I would like to state these Commandments for contemplation in your own operation:

1. Thou shalt always remember that thy Green Chairman (Parks Director, Golf Director, General Manager, etc.) is thy boss, in spite of his/her knowledge of golf course maintenance. I have seen more superintendents lose their jobs over this single point than any factor involved in golf course management. As superintendents, we are hired to provide the best playing conditions at all times for the playing membership. I will never forget Milt Bauman's comment that, "If they want it purple,

give it to them purple! But, if they want it purple, and you know it will do harm to the golf course, then have them put it in writing!'' This strong, yet flexible attitude has been seen on many golf courses in the western United States where outstanding operations are being conducted. It is extremely difficult for anyone to have an inexperienced superior begin giving directions; however, it is our job to educate that person to the many difficulties facing the golf course superintendent.

2. Thou shalt treat thy crew as thou would like to be treated. A basic concept that not only goes on the job but in life as well. Most successful superintendents realize that the backbone of their maintenance operation is the staff and their success is dependent upon the abilities of that staff.

3. Thou shalt use water when it is needed and as sparingly as possible. While this may not be an issue in the western portions of the Pacific Northwest, it has become a big issue in the State of Arizona, Southern California, and will become a bigger issue in the Pacific Northwest. As you have already heard at this Conference, exciting research with potassium is developing interesting responses with regard to drought and I feel it behooves everyone in this room to use as little water as possible to provide firm and fast playing conditions, without losing turf. The concept of wall-to-wall green throughout our courses may become a thing of the past as the water situation in the United States becomes more critical.

4. Thou shalt apply all chemicals safely and educate the uninformed about the true potential danger of our various chemicals. From what I have seen in the western United States and across the country, we are at war with the ''Environmentalists''. The war is being fought in the national media and it appears, from recent decisions, that the turf industry is losing many battles. It behooves us all to educate our membership, neighbors, and the maintenance staff about the facts surrounding our chemical usage.

5. Thou shalt freely share ideas and experiences with fellow turf professionals. The old saying ''no man is an island'' would certainly apply to golf course turf managers. The willingness to share ideas brings the whole profession up to a higher plane. The golf course superintendents I have viewed who have the very best results are givers, not takers!

6. Thou shalt educate thy membership about all aspects pertaining to golf course maintenance. Good communication with the entire membership is the key to a smooth running operation. Whether it is through the club newsletter, bulletin boards, playing golf with the members, or more modern techniques, an open flow of information must be kept for the best results.

7. Thou shalt educate thy crew in all aspects of thy operation and provide regular safety meetings.

8. Thou shalt play the game of golf and, if not, thoroughly understand its rules and etiquette. Another one of the most common complaints I hear from green committee chairmen or members is, "The superintendent doesn't even play golf so he doesn't understand what we want." In most cases, this is a bunch of baloney! However, the members (the boss) do not view this situation in the same light. Developing an active interest in the game will at least put on an equal mental frame (in the member's eyes) with the golfing members at the course.

9. Thou shalt take advantage of all educational opportunities. Your attendance at this Conference is a good example of this important point.

10. Thou shalt make every effort to support the GCSAA/USGA Research Program in the development of new grasses for minimal maintenance. Research that will have a profound effect on maintenance practices in the Pacific Northwest is ongoing. Should Dr. White's research work at the University of Minnesota provide a seeded, stoloniferous type of *Poa annua*, the effects, for the Pacific Northwest, would definitely be felt. In the meantime, every effort should be made to continue to increase bentgrass populations and ward off the heavy seeding types of annual *Poa annua*.

Many of the aforementioned "Commandments" are very basic and done by all of us in the room, all of the time. Others are forgotten and done on a part time basis, while still others may be completely left out of our operation. I would urge all of you to think about these ideas and take them back with you to your individual golf courses for use in your daily, weekly, monthly and yearly programs.

TRUE CONFESSIONS REVEALED!

During this past spring, Tom Cook sent me an invitation to speak before you with the aforementioned title. His directions were to come up with something for the title that would be fitting! After mulling over this topic for several months, I must confess that I don't have enough time to make all the confessions I need to make about being a USGA Agronomist. I freely confess that when I joined the USGA, I knew little about bermudagrass, hybrid bermudagrass, kikuyugrass and growing grass under some of the worst environmental conditions imaginable. I freely confess that when I joined the Green Section, I did not feel comfortable being called an agronomist as I was simply a grass grower. It has taken three years but that hurdle has finally been crossed! However, most of all I must confess that working for the United States Golf Association has been a very positive experience and has certainly given me a different perspective of the Green Section from the other side of the fence. We used to always relish the visits of Bill Bengeyfield, Don Hoos and Tim Ansett at Seattle Golf Club as we realized the Green Section is a tool to be used for improving the golf course operation. I truly feel that no man is an island and one of the best tools available in the turf industry today is the USGA Green Section. I have heard various myths about the Green Section such as the

USGA Agronomist costs people their jobs and the Green Section agronomist always sides with the superintendent. Or how about, ''I'm a professional turf manager. I don't need any help!'' and ''He's not from this area. He can't grasp my problems in one day!'' If you feel this way, then the Green Section is definitely not for you; however, how will you know if you never give it a try?

I would like to conclude my topic by making one last confession. I must confess that without gentlemen such as Roy Goss, Milt Bauman, Tom Cook, John Monson, Al Law and others in this room and outside, I do not feel I would be standing here before you giving this presentation. I would like to thank you all for giving me this opportunity to again speak before the Northwest Turfgrass Association and look forward to the continued excellent association the USGA and NTA have had in the past.

FUNGICIDE EFFECTS ON DISEASES AND THATCH[1]

Richard W. Smiley[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

[2] Professor of Plant Pathology, Oregon State University, Columbia Basin Agriculture Research Center, Pendleton, OR.

The efficiency of pesticides (fungicides, herbicides, insecticides, nematicides, etc.) for controlling intended (target) pests is well known. In contrast, very little information is available regarding the side effects of these chemicals on other (nontarget) organisms and turfgrass processes. Beneficial as well as deleterious nontarget effects surely occur, but they continue to be one of the least understood aspects of pesticide use. If the beneficial nontarget effects can be identified and exploited and the deleterious nontarget effects minimized, the economics and efficiency of turfgrass management could be improved.

A voluminous data bank is available to illustrate the efficacy of specific fungicides for controlling each disease. The positive results from such research are thoroughly extended to turfgrass managers. Moreover, the labels on fungicide packages list all registered uses. In contrast, the negative or inconclusive results of disease control studies are communicated less frequently, and our knowledge of nontarget effects is limited. In particular, few articles emphasize the instances where fungicides have increased the prevalence of one or more diseases, or affected processes such as thatch accumulation. This paper will concentrate on that void.

DISEASES

Turfgrass managers periodically experience occasions when a fungicide application seemingly allows a particular disease to become more severe. On other occasions the fungicide controls the target disease, but soon thereafter, a second disease becomes noticeable. On uniformly treated turfgrasses, the causes for these occurrences are seldom identifiable if they are noticed at all. Such observations are, however, often dramatic and quantifiable on replicated research trials. During the past decade, over 100 examples of fungicide-induced increases in turfgrass diseases have been listed in technical journals, such as *Fungicide and Nematicide Tests*, a publication of the American Phytopathological Society. Even these reports are thought to greatly underestimate the numbers of actual occurrences of such observations in research trials. Data from some of the technical literature have been summarized in Table 1.

Benzimidazole-derivative fungicides, such as benomyl (Tersan 1991) and the thiophanates (Fungo, CL 3336), have been given considerable attention during the past 15 years. Very early, in research labs, these chemicals were recognized as being non-toxic to *Pythium* and related fungi, and toxic to many other organisms that occur in turfgrasses. Thus, the potential existed for Pythium blight to respond to applications of the benzimidazoles by being 1) unaffected, 2) suppressed by some indirect effect, as with a fungicide-induced biological control that depends on competitive activities of other organisms and fungi in the turf, or 3) amplified by some indirect effect, as when sufficient competing organisms have been suppressed, or when the metabolism of the host has become altered so that the plants become more susceptible to the disease. Research and commercial practice quickly showed that options 1 and 3 could be identified as being present and important.

The benzimidazoles were also known to be nontoxic to many other fungi, and scientists were not surprised when they were found to be capable of amplifying diseases caused by those fungi. Documentation for this activity in the field is now available for Typhula blight, rusts, red thread, fairy ring, and some diseases caused by *Rhizoctonia* and *Helminthosporium* species. The lack of control of dollar spot by benzimidazoles in certain areas represents a special circumstance in which strains of the pathogen have undergone adaptive mutation or selection and thereby become tolerant of these fungicides. There are also instances in which a disease that had been diagnosed as dollar spot did not respond to applications of benzimidazoles, when in fact the true identity of the disease was, at a later date, considered uncertain.

There are many other instances in which fungicides have caused diseases to become more severe, or to occur where they may not have if the fungicide had not been applied. Table 1 summarizes some of these observations. Some specific examples are described by A. D. Brede in the June 1980 issue of *Golf Course Management* and by myself in the January 1981 issue of *Plant Disease*. There are also instances where chemicals have failed to control the diseases that are normally controlled easily, or where fungicides have led to traumatic, unexpected killing of grasses. In this paper I will describe just three of the many experiences the author has been associated with on New York golf courses.

The first example occurred during a study designed to evaluate chemicals for controlling Fusarium patch and Typhula blight. Neither of the intended diseases occurred on the golf course that year, but a cold weather form of brown patch, caused by *Rhizoctonia cerealis*, occurred on 17 greens treated with chloroneb (Tersan SP). The disease was absent on the untreated practice green and on untreated areas of the one playing green on which the author was evaluating chemicals to control Fusarium patch. On the latter green, the disease was only present where chloroneb or cycloheximide (Actidione TGF or Actidione Thiram) had been applied. The disease was absent where PCNB (Terraclor) or mixtures of PCNB and cycloheximide (Actidione RZ) were applied. Reasons for the unpredicted occurrence of this disease and for its unsuspected response to the golf course's protective fungicide program would have been far from clear if the research trial had not also been conducted on this golf course.

The second example involved diagnostic work conducted on a course where a low rate (0.5X) of fenarimol (Rubigan), used to control dollar spot, killed most of the annual bluegrass on five greens of a golf course. No precedent for this toxicity was known, and it was rather certain that the application rate and technique were not faulty. The weather also did not seem to have an effect on this incident. Further investigation showed that the superintendent had been using a soil acidification program to weaken the annual bluegrass. It is well known that fenarimol is also toxic to grasses when applied at high rates, or too frequently. The conclusion was reached that the fenarimol and soil acidity acted synergistically to cause a dramatic and disruptive killing of the annual bluegrass, whereas neither of the individual practices were conducted at a level that would be lethal.

The third example occurred on a golf course where Fusarium blight (now known to have been the summer patch component of the complex) became uncontrollable with applications of benoyml (Tersan 1991). This occurred gradually over a period of about 3 years. The use of arsenate was curtailed when it was removed from the market. Applications of triadimefon (Bayleton) were effective in controlling the disease, except where additional applications of tricalcium arsenate were applied on an experimental basis. When arsenic concentrations in soil were high, all fungicides were ineffective against the disease. Research illustrated that commercial applications of arsenate, to remove annual bluegrass, had increased the level of environmental stress on the Kentucky bluegrasses to such an extent that they became so highly susceptible to the disease that benomyl was unable to control it. After several years in which the arsenates were not applied, the ability of benomyl to control Fusarium blight gradually returned and the severity of disease declined. Later, the disease quit occurring on the fairways, just as had been the case before the arsenate program had been initiated. However, residues of arsenic are long lasting, and Fusarium blight can still be induced on this golf course by simply applying small amounts of this herbicide.

THATCH

Thatch accumulates in turfgrasses when the annual rate of tissue production exceeds the rate of tissue decomposition. The rates at which these processes occur are greatly affected by environmental conditions (temperature, water, pH, nutrition, microbial activity, some pesticides) that may or may not be altered through cultural practices. In cool-temperate climates tissue production occurs most rapidly during the mild weather of spring and autumn, and decomposition is most rapid during mid-summer, unless some characteristic of the thatch environment (too wet or dry, too acid or alkaline, too little nitrogen) restricts these processes when they should be occurring at their maximum rates. It has been observed that some chemicals, when used frequently or at high rates, have caused turfs to accumulate more thatch than occurs in nontreated turfs. Such is the case with the fungicides benomyl (Tersan 1991) and iprodione (Chipco 26019). The author studied this phenomenon for 10 years in several long-term replicated fungicide trials in upstate New

York and on Long Island. Results of those studies are summarized here.

In one study 14 fungicides, 1 nematicide, and 5 mixed-fungicide programs were applied repeatedly to replicated plots in a Kentucky bluegrass turf. Applications were made from 1 to 9 times annually over a 4-year period. After 3 years the depth of thatch in these plots varied from 2 to 22 mm (25.4 mm = 1 inch), with the untreated control having 6 mm. Treatments that caused thatch to accumulate significantly were those that included several to many applications of the fungicides thiram (Tersan 75, or mixed products such as Bromosan), maneb or mancozeb (Dithane M-45, or mixed products such as Fungo), cadmium (Cadminate), and benomyl or thiophanate (Tersan 1991, or mixed products such as Bromosan or Fungo). Applications of the nematicide fenamiphos (Nemacur), made once each year for 3 years, also caused thatch to accumulate. Some of the treatments caused a significant acidification of turf and its underlying soil, even though lime was applied as a surface broadcast. The causes of these effects were not clearly identified during the early phases of the study, and later studies were unable to duplicate the extensive acidification response. Fungicides which did not cause thatch to accumulate or soil to acidify included cycloheximide (Actidione TGF or Actidione RZ), captan (Captan), chlorothalonil (Daconil 2787), anilazine (Dyrene), quintozene (e.g., PCNB, as in Terraclor and Actidione RZ), and ethazole (Koban).

Additional data were also collected on numerous other effects of the 20 chemical treatments and the nontreated control, including changes in disease, weed, and insect patterns, in microbiological populations in the thatch layer, in turfgrass characteristics (density, color, quality), in root density, in leaf clipping production, and in the shear (tearing) strength of sods cut from the plots. The fungicides affected all of these nontarget characteristics on one or more of the dates in which data were collected. Additionally, samples of carefully weighed natural thatch, from a nearby plot, were enclosed in nylon-mesh bags and buried at 2-cm depth (3/4 inch) in the treated areas for various lengths of time, up to 2 years. The bags were then recovered, cleaned, and reweighed to determine the rates of thatch decomposition. We could not measure consistent differences in decomposition rates among any of the treatments, as compared to the unsprayed control. In short, it became clear that the fungicide treatments that caused thatch to accumulate did not significantly reduce the rate of tissue decomposition, but did alter the rate of tissue production. This is contrary to what had been anticipated, and led to more extensive tests.

Treatments in the latest, more exacting, test included the fungicides benomyl (Tersan 1991), metalaxyl (Subdue), iprodione (Chipco 26019), triadimefon (Bayleton), propiconazole (Banner), and cycloheximide (Actidione TGF). Benomyl and iprodione again caused thatch to accumulate when the treatments were applied 7 times each year for 6 years, but not when applied 3 times annually. None of the other fungicides caused thatch to accumulate. In no case did any of the fungicides cause a measurable change in thatch or soil pH, in the decomposition rate of buried thatch, or in the microbial composition of thatch. Results of this study supported the concept that fungicides which cause thatch to accumulate are likely to do so by increasing the rate of tissue production without changing the rate of tissue decomposition. Detailed results of these tests are available in the references listed at the end of this paper.

SUMMARY

It is readily apparent that fungicides cause nontarget effects to occur in turfgrasses. In addition to direct effects, each resultant chemical and biological change may cause secondary, tertiary, and other changes until the entire management program becomes improved or hindered by the use of certain pesticides. The likelihood for this to happen with fungicides is, however, restricted to those areas that are highly maintained. Under low levels of management, it is probable the nontarget effects will be so slight as to be undetectable. In practice, putting greens and bowling greens are more subject to interactions of chemicals and management practices than any other types of turf. Existing knowledge of nontarget effects should, however, be incorporated into the original decision-making process. If, for instance, four fungicides were known to be almost equally effective against a target pathogen but two were much more likely to increase thatchiness, this information could be used to avoid long-term increases in the costs of managing the golf course. Management costs that could persist for many years may very well over-ride the immediate differences in costs for the products and their application.

There are few actual guidelines that can be presented at this time, because our knowledge about the multitude of possible complicating factors is very meager. All managers of fine turf should, however, use pesticides as judiciously as possible, and pay strict attention to the potential that they may have for causing effects other than those for which they are intended. Many additional examples can be presented to illustrate the horror stories that have occurred through the overuse or misuse of pesticides on turfgrasses. A conservative approach will usually help managers to avoid having their experiences added to these lists.

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Table 1. Increases in turfgrass disease severity associated with treatment of plots with fungicides*

	Helminthosporium leaf spot	Dollar spot, copper spot	Red thread	Rust	Stripe smut	Yellow tuft	Rhizoctonia diseases	Fusarium blight	Fusarium patch	Typhula blight
Actidione	...	...	...	...	...	...	S	...	...	N
Bayleton	N	...	...	...	...	N	...	...	...	...
Banner	...	...	S	...	...	...	S	S	...	...
Chipco 26019	...	...	...	...	N	S	...	...	...	...
Daconil	S	S	...	...	I	...	...	S	N	N
Dyrene	...	I	...	...	N	...	...	S	N	...
Heavy metals (cadmium, mercury)	I	N	...	...	...	...	N	...	...	...
Koban	N	I	...	...	...	...	I	...	N	...
Terraclor (PCNB)	...	S	...	...	S	...	S	N	...	...
Tersan 1991, Fungo, CL 3336	S	S	S	S	...	...	N	...	...	N
Tersan LSR, Fore, Dithane M-45	...	S	...	...	...	...	...	...	S	...
Tersan SP	...	...	...	...	...	...	S	...	...	...
Thiram and combination products	S	S	...	...	N	...	S	...	N	...

*S = significant increases in at least one study, I = increases that appeared important but statistical analyses were not performed, N = increases that were not statistically significant.

BUNKER DESIGN, LAYOUT AND CONSTRUCTION[1]

John Steidel[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
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Each golfer I know has a little bit of golf course architect in him, especially when it concerns the course he plays regularly. Many of these "arm chair architects" feel that they play a good golf course and if they could put in just a few fairway sand traps and maybe lengthen some tees, it would be even better. Unfortunately, when these golfers get on the governing boards of their courses, they often put those traps in without sufficient thought and knowledge and very often without sufficient funds which tends to preclude the involvement of a golf architect and experienced golf course construction personnel.

Many of these additional sand traps are placed on the fairways with the work done by the golf course superintendent and his crew. My talk today, "Bunker design, layout and construction", is prepared to provide the superintendent additional information on these subjects, especially if he is requested to do this work without the benefit of professional design and construction help.

I wish to suggest to you that there are at least six steps you should follow when attempting to construct or reconstruct fairway sand bunkers on your course.

1. *Be convinced that the bunker is necessary*. When your Green Committee Chairman comes to you one day and says, "We need a fairway bunker on the right side of the third hole", see if you can slow him down a bit. If possible, consider not only what the construction of this sand bunker will do to the hole, but also to that particular nine and the course as a whole. When I am working with a remodeling client, if at all possible, I try to prepare a Master Remodeling Plan for their entire course where this is evaluated.

There is some danger of weakening a good hole by adding a fairway trap that makes a hole either harder by making the hole too demanding, or easier by keeping a golfer out of trees or a hazard to be avoided. Begin by seriously asking yourself or better yet, your Green Committee Chairman, "Is this sand bunker really necessary?" Most courses cannot afford time and money to build and maintain traps that are out of play. Alister Mackenzie, perhaps the greatest Golf Architect ever, had among his principles of golf course design to never build even one more trap than necessary. If your answer is still yes, you then must determine the proper location for it.

2. *Make sure the bunker is properly located.* The proper location depends upon many factors including length of hole, type of hole, fairway slope, firmness of fairways, prevailing wind, and who plays the course as well as which golfers you are trying to affect. I try to place fairway traps at a distance where a scratch golfer cannot carry them yet a high handicapper cannot reach them when playing from the same men's regular tee. This is not always possible, so occasionally long or multiple traps are required, or choosing which goal is more important to achieve in this particular instance.

Most commonly fairway bunkers are placed to narrow the driving area for good golfers. The narrowing of fairways by this means and the mowing less fairway and more rough is a definite trend that has been occurring over approximately the past five years. Other reasons given for the use of fairway bunkers are that they define or frame a landing area, become a target for golfers to aim at or speed up play by keeping drives from going into a hazard, rough, or trees. The latter two reasons, if acted upon, probably will result in unnecessary traps and eventually cost your course.

Whenever planning a course, I use fairway bunkers to increase both the challenge and variety of a course. I prefer strategic bunkering of fairways where the best tee shot is one that is closest to the fairway trap because it opens up the approach to the green. But for better variety, not all holes should be bunkered in this manner. Neither should the corners of all doglegs be bunkered. Sometimes adding fairway sand traps to the outside edge of a dogleg will create strategic bunkering if the green is bunkered properly. Again, penal bunkering of a hole, especially on a residential development golf course, may be necessary and the only option.

3. *Plan ahead what you want to do and how you want to do it.* Once you have decided where a fairway bunker is to be placed on a hole, you must find out how to build a fairway bunker properly. The evidence I have seen on many courses indicates that isn't as easy as it seems. Most "do-it-yourself" bunker construction falls far short of what is attempted in new golf course construction because courses and clubs are reluctant to spend appropriate funds to do the job right and superintendents are reluctant to disturb a large area of existing turf to elevate it enough for good visibility and drainage because of the amount of fill material required and because of the amount of re-seeding or re-sodding that will be required.

You should begin with a plan or a very clear idea of what you would like the result to be. When you lay out a fairway sand trap using a plan, one distinct advantage is that the limits of fill can be scaled off the plan so that you know exactly the area where sod needs to be stripped and which irrigation heads are affected.

I am convinced that the most common mistake made in bunker construction on existing courses is that not enough fill is used to make the new hazard visible from where the previous shot was hit. Almost any sort of hazard is fair on a golf course if it can be seen prior to the shot so that it can be avoided. The best fairway bunkers are built into a mound or mounds that elevated them enough to insure visibility. You most certainly want to avoid spending a lot of time and money constructing a hazard that can't be seen. When I stake my own work for clients most after locating the bunker center, all I locate initially are mounds and their elevations so that the right amount of dirt can be brought in and rough graded. Rough grading allows me to make adjustments to achieve the desired visibility.

4. *If at all possible, hire an equipment operator who has built bunkers on existing courses before.* When I began my work in golf course architecture almost fifteen years ago, while working for another golf architect, I read in his specifications that backhoe was not to be used for bunker construction. The reason for that was not apparent at that time. When I first built a golf course in Montana ten years ago, we built all our traps with a D-6 and a backhoe because that was all we had available. Then I felt that the results were satisfactory, but knew without an exceptional amount of hand-work, using a backhoe on a bunker generally produces an unstable edge that is too steep, where the sand is too deep, causing balls to bury.

Experienced golf course contractors who specialize in fine grading of golf courses work with amazing speed and, with their specialized equipment, can shape a trap in just a few hours. The right operator can leave you with but a minimal amount of hand work, mostly raking to prepare the mound for seed and the bunker basin for sand.

When I wrote an article on remodeling sand bunkers for the USGA Green Section Record last year, I mentioned that I have been guilty in the past of worrying too much about how a trap was going to look and not enough about where they were placed and how they would play.

How bunkers look is a matter of personal opinion only. There are a number of very good golf courses where the bunkers are "bombshell" in nature and all similar in size. We have recently gone through a period where many architects were building sand bunkers that were curvilinear, often with sand flashed up the sides for visibility, which is still my personal preference. Now, the popular trend is to build traps where the sand is flat on the bottom and it is surrounded by steep grass slopes. When I am adding sand bunkers to an existing course, I try as much as possible to match the style and appearance of their existing bunkers.

Part of how bunkers look depends upon how well they are maintained. How bunkers are designed affects difficulty and ultimately cost of maintenance. If the sides of bunkers are steep, whether they are sand or turf, they will be more costly and difficult to maintain. Maintenance costs depend more on the amount of edging required than the size of the bunker. Simple bunker shapes will cost less to maintain. I prefer a curvilinear shaped bunker where fingers and grass are constructed with adequate turning radii for machine maintenance. It also would cost less if you could convince your membership to let bunker edges get shaggy once in a while, but that is a hard concept to sell.

5. *Build the bunker right*. More important to those who play your course, than how a bunker looks and is maintained, and at least equal in importance, to where it is placed, is how the bunker plays. I often hear good golfers tell me to make sure when I build a fairway bunker to keep the lip low so that they can recover from them. This generally is a good idea. If a fairway bunker is 150 yards from a green, the lip should be low enough that a good golfer can hit a seven-iron out of it. Par 5's should probably be treated differently. On those holes, it is not necessary to build lips low enough for a three wood, since golfers still have two shots to get to the green in regulation.

When reconstructing fairway bunkers, often a primary concern is to make them more visible by raising edges or parts of the bunker. Sometimes there will be slopes and lies that a golfer encounters in bunkers that are difficult and make reaching the green in regulation a remote chance. As we all know, golf is not always fair. If you can see the hazard and the shot required to avoid it isn't overly difficult, then you shouldn't be in it anyhow. With the length some courses presently grow their rough, sometimes the golfer is better off in the hazard than in the rough anyhow—just as Greg Norman or Bob Tway.

There is no magic formula for proper sand trap construction. What works in one area might not work in another. What works for one superintendent might be unthinkable for another. What works for one club might be intolerable to another.

I do believe that some amount of hard work is essential. If you don't do it during construction, you will do it sometime. Always install drainage, usually interior drainage or interior-exterior sumps. Put in the best proven sand trap sand you can afford. You can usually find one you like by talking to other superintendents in your area and asking your golfers their opinion. The USGA can also test prospective sands and give you their opinion. The proper sand trap depth varies depending upon whom you ask. I have heard anywhere from two to twelve inches, but I usually recommend six.

I have been very disappointed with the results of linersin sand traps. They are costly, unnatural and a nuisance. When club members say, "What about grass bunkers?" they are usually thinking about something they saw on television or played in Palm Springs which are headaches for golfers and superintendents alike. We have grass bunkers here in the Pacific Northwest. They are the overgrown bunkers your club couldn't afford to maintain twenty years ago.

6. *Get the job done*. In the eyes of many of your golfers, how successful your project is depends in a large part how little they are inconvenienced. If you can schedule any golf course remodeling away from important dates, tournaments, and

heavy play, do so. No one likes to have drop areas or to play temporary holes, especially those paying the bills, any more than possible.

Be ready to disconnect sprinklers, strip sod and go. Have your dirt, sand, and gravel sources ready, trucks available, and your operator and equipment committed to your project. Then work as long and hard as you can until the job is done. Whether you seed or sod your work is up to you. Seeding, especially hydromulching, is better in the long run, but sometimes the extra work and cost of sodding is of great value to your Public Relations.

In summary, let me leave you a short checklist you should go through if you are asked to build a fairway bunker on your course.

1. Be convinced that the sand bunker is necessary. Evaluate its affect not only on the particular hole, but on the entire course as well.

2. Make sure the bunker is properly located. You probably don't want it constructed where it is out of play or where it affects only high-handicap golfers who don't need the additional aggravation anyway.

3. Plan ahead what you want to do and how you want to do it. Preparing at least a sketch plan will allow you to estimate quantities of fill and sand required and establish the limits of clearing.

4. If at all possible, hire an equipment operator who has built bunkers on existing golf courses before. He will do a better job, much faster than you or inexperienced equipment operators can.

5. Build the bunker right. Grade the bunker basin and established the bunker edge, considering how it will play and making sure it will drain. Then step back to where the shot will come from and make sure the bunker is visible.

6. Finish construction and cleanup as fast as possible. Choose seeding or sodding carefully depending upon how long your golfers will tolerate ground under repair.

It is my hope that this talk and my suggestions will be useful to you should you be handed fairway bunker construction projects in the future. As one who golfs the entire Pacific Northwest, I want to see fewer poorly executed remodeling projects and play more exciting golf courses.

IS CONTOUR MOWING HERE TO STAY?[1]

John Ford[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Golf Course Superintendent, Tacoma Country and Golf Club, Tacoma, WA.

Just over four years ago I began working with our golf professional, Gerry Mehlert, on a contour mowing program for the fairways at Tacoma. We had an interested Green Committee and a membership that was ready for some changes. I will share with you our initial guidelines, the cost of converting to this program compared to pre-contour mowing costs, our projected costs and, finally, what I see as the advantages and disadvantages that have become evident over the past four years.

The general guidelines were that there would be a moderately wide landing area of approximately 30 yards in width every 150 yards through the green. These landing areas would accommodate the ladies play. The second landing area comes between 170 and 230 yards off the tee. This would be the widest landing area of about 35 yards in width. This area is intended for the men's drives. From here, the fairway narrows down to 20 to 25 yards in width at between 240 to 260 yards off the tee. The width then increases to approximately 30 yards again at the 300-yard mark off the tee. From here we follow the 150-yard rule through the green on par 5's. Not all holes play to fit into these guidelines so on holes that play shorter or longer than their yardage, we adjusted the landing areas accordingly.

This change in mowing pattern resulted in a reduction of from 40 to 25 acres. A good part of the reduction came by mowing fairways beginning out between 50 and 75 yards from the tee.

Mowing equipment has changed also. We had been mowing with a F-10 7-gang and a triplex for approaches. This combination took an average of nine hours per mowing. Looking to reduce compaction with lighter equipment as well as desiring hydraulicly driven reels, we converted to a Ransome 5/3 and a Toro Greensmaster III triplex. The triplex mowed par 3 fairways and two par 4's as well as all approaches. The Ransome mowed all remaining par 4's and par 5's. This combination, despite the reduction in acreage, took an average of 12 hours per mowing.

Two main goals were to increase the playing quality of the turf and the playability of the course. Density of the turf was not what it should be, so by reducing our fairway acreage, it became affordable to begin a vigorous overseeding program. This not only improved density, but helped outline the contours. Playability was increased due to better quality turf and due to a decrease in the mowing height of the rough. All rough had been mowed at 2 inches in height prior to contour mowing. Due to the new tightness of the fairways, it was decided to mow two cuts of rough; a primary rough of approximately five yards in width at a height of 1-1/4 inches, and a secondary rough mowed at 1-3/4 inches in height. Tacoma has enough trouble with bunkers and trees off the fairway that tough rough is not necessary. This program allows members to play tight fairways without much penalty for being in the rough. It also gives us flexibility to grow rough when needed for more demanding conditions.

Being always concerned about the cost of what we do, I have the cost of our programs. First, I will outline the cost of our pre-contour mowing program. I figure the F-10 cost us an average of $3,300 per year. The triplex was values at $2,500 per year. The total for equipment was $5,800 per year. The total for labor at $7.00/hour, at 9 hours per day and 132 days per year come to $8,316 per year. Seed costs for spot overseeding came to about $500 per year. The total cost, adding all of these factors, comes to $14,616 per year.

To convert to contour mowing, the club purchased a Ransome 5/3 mower and a Toro Greensmaster III triplex mower. I figured an annual expense of $3,140.00 for the Ransome 5/3 and $2,500.00 for the triplex mower. Labor for this program was calculated at $7.00/hour at 12 hours per day for 132 days per year. This totals $11,088.00 for labor. An increase of $4,000.00 for overseeding brings the total for the contour mowing program to $20,728.00 per year. This is a $6,000.00 increase when compared to our pre-contour mowing program.

Our initial plan also included the desire to use all triplex mowers. As you can see from the increased cost of converting to the Ransome 5/3, it would be quite expensive to convert completely to triplex mowers. Therefore, we have decided to add another 5/3 unit which will reduce our mowing time to seven hours per day. The total annual cost for this program will be about $18,500 per year which is $2,000 less than our present program. This addition will allow us to completely mow fairways and approaches in three hours or less.

Now let's look at the advantages and disadvantages of contour mowing. First the disadvantages. I have experienced two disadvantages over the past four years. The first is that the mowing pattern can only be one way. We have 400 golfing members, any one of which may wonder why there is rough where his drive lands and fairway ten feet further where his opponent has driven. I have learned that the location of the actual fairway edge is an evolutionary process. Our initial guidelines were quite tight, but the Green Committee and membership were excited about the changes and went along with the program at the time. It took about two years for the members to start asking for changes in certain areas that they felt were too demanding. The Green Committee responded by making hole-by-hole recommendations as questions came up. This process has gone on for the last two years with changes being made in the spring and with each committee being satisfied once the changes were made. The master plan work that has been completed so far has helped to make location of the fairway edges more obvious and attractive.

The other disadvantage is that it takes a lot of time and effort to educate the members so they will undersand what the goals are and how they will benefit from contour mowing. I list this as a disadvantage only because most of us have enough to do without trying to sell a contour mowing program. Your golf professional, Green Committee and club newsletter can all be helpful in this process.

I am happy to say that the advantages far outweigh the disadvantages. The first and most obvious advantage is that contour mowing should save time and money. This is true if you reduce your acreage and continue with the same equipment, etc.

The second advantage is the ease with which the edge can be changed. You must always remember that the members own the course. If they want a change in an edge, it is easily done. Nothing is in concrete.

The third advantage is that contour mowing has allowed my staff to improve turf quality and course playability. My staff has received many compliments from members for the improvements that they have made in the past four years.

The fourth advantage was the additional equipment that was purchased for this program. We now have adequate back-up mowers in case of a major breakdown.

The fifth advantage is that the lighter equipment has greatly reduced wear from the mowers. This has resulted in a steady increase in our bentgrass population. Also, with the addition of a second 5/3 mower, we will be able to mow the entire course, less the rough, in three hours.

The final advantage is that the overall appearance has improved. This is especially true on the remodeled holes. The golfer who is aware of the contour edges has a better idea of how to play the hole.

So, Tom asks is contour mowing here to stay? I say YES! As long as the players like it and the superintendents are willing to do what it takes to sell the program.

THE EFFECTS OF RUBIGAN (FENARIMOL) ON ANNUAL BLUEGRASS AND CREEPING BENTGRASS[1]

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INTRODUCTION

Annual bluegrass (*Poa annua*) is a major weed problem in fine turf. It exhibits a light green color, has a low tolerance to environmental stress, is a prolific seed producer in the spring, and is able to withstand close mowings. All of these factors make annual bluegrass undesirable to the golf course superintendent. On a creeping bentgrass (*Agrostis palustris*) putting green, annual bluegrass infestations are first seen to be the size of a quarter. If left unattended for a couple of years, these patches can grow to become one to two feet in diameter. For this reason, finding a control measure for annual bluegrass is desirable.

Many different approaches have been tried for controlling annual bluegrass in turf. Some of the more popular methods have employed alterations in cultural practices, and the use of pre and post-emergence applications of herbicides. While many methods have been used, none to date have had wide sweeping success in eliminating annual bluegrass from fine turf without injuring the desirable species. A relatively new approach for eliminating annual bluegrass from creeping bentgrass is the use of Rubigan, a broad spectrum fungicide distributed by Elanco.

Rubigan is currently registered for use against the following turf diseases: dollar spot (*Sclerotinia homoeocarpa*), copper spot (*Gloeocercospora sorghi*), large brown patch (*Rhizoctonia solani*), necrotic ring spot (*Leptosphaeria korrae*), summer patch (*Phialophora graminicola*), Fusarium leafspot and crown rot (*Fusarium roseum*), stripe smut (*Ustilago striiformis*), pink snow mold (*Gerlachia nivalis*), gray snow mold (*Typhula* spp.), and red thread (*Laetisaria fuciformis*) (1). Besides acting as a fungicide, Rubigan may also work as an herbicide by selectively reducing annual bluegrass populations in turf. It has been shown that Rubigan interferes with the synthesis of gibberellic acid (2). It is this inhibition of gibberellic acid, the main plant hormone responsible for cell division and elongation, that results in reductions of annual bluegrass populations.

While it is clear that Rubigan modifies shoot growth of annual bluegrass, there are still a few questions about its effect on seedling emergence and root growth of annual bluegrass and creeping bentgrass. For this reason, it is the objective of this study to: 1) evaluate the effects of Rubigan on creeping bentgrass and annual bluegrass seedling emergence; 2) determine the effects of Rubigan on root and shoot growth at various growth stages of annual bluegrass and creeping bentgrass; and 3) investigate the effects of Rubigan on annual bluegrass and creeping bentgrass root growth.

MATERIALS AND METHODS

For this study two biotypes of annual bluegrass (*Poa annua*) were used. One was collected from Olympia, Washington, and the second was collected from Pullman, Washington. Both biotypes were of the annual type of annual bluegrass, on which Rubigan is reportedly more effective (1). The cultivars of creeping bentgrass (*Agrostis palustris*) that were evaluated were Penncross and Emerald. Both the annual bluegrass and creeping bentgrass varieties were seeded at rates of 1 lb pure live seed per 1000 ft^2.

Seeds were planted in 4-inch "pine cell" conetainers. The growing media used was a straight sand composite which had been washed to remove any fine silt particles, and screened through at 16-mesh screen to remove any small gravel and large sand particles. Plants were maintained in the greenhouse under conditions favorable for growth.

Rubigan treatments were applied to all species pre-emergent, and at the one-, two-, three-, and four-leaf stages of growth. Plants were sprayed using a greenhouse bench sprayer which applied treatments by passing plants under a stationary nozzle by means of a conveyor driver tray. Single applications of 0, 0.2, 0.4, 1.0, 2.0, and 4.0 oz Rubigan 50W per 1000 ft^2 were applied to each species and at each stage of maturity. Plant height, root dry weight, and quality ratings were taken two weeks, four weeks, and six weeks after applications. For the pre-emergence evaluations, the number of living plants present were counted two weeks, four weeks, and six weeks after treatment.

Roots were washed by emptying the cones onto a 9-mesh screen and using running water to wash the sand through the screen. This procedure allowed the sand, which had been previously sifted through a 16-mesh screen, to pass through the larger holes of the 9-mesh screen, leaving only the root material on the screen. The root masses were then placed in an oven dryer at 55 °C until dry. When dry, the roots were weighed using a Mettler AE 100 electronic balance.

RESULTS AND DISCUSSION

Since small differences due to the particular biotype of annual bluegrass or variety of bentgrass were expressed, comparisons between biotypes and varieties will not be made.

Looking first at the effects of Rubigan on the emergence/survival of creeping bentgrass and annual bluegrass (Figures 1 and 2), it can be seen that Rubigan caused greater reductions int he emergence/survival of the bentgrass than of the annual bluegrass. All rates of Rubigan applied to the bentgrass caused at least a 15 percent reduction in the number of living plants present six weeks after treatment. This is compared to the response of the annual bluegrass, where only the 4.0-oz rate caused greater than a 20 percent reduction in presence of living plants after six weeks. These results indicate that caution should be taken when applying Rubigan to newly seeded bentgrass turf, and that Rubigan's affect on annual bluegrass may not warrant its use as a pre-emergent control method for annual bluegrass.

Besides limiting seedling emergence/survival, Rubigan applications also have an effect on creeping bentgrass growth at the one- and four-leaf stages of growth. With plant height used as a means of measuring plant growth, it can be seen from Figure 3 that applications of Rubigan inhibit the growth of Penncross at the one-leaf stage. While the low rates of Rubigan (0.2 and 0.4) caused a reduction in plant height, rates above 0.4 oz totally suppressed the growth of Penncross for the duration of the study. These results can be explained by the growth regulating affects caused by Rubigan, as was mentioned earlier.

At the four-leaf stage (Figure 4) it can be seen that the rates of 1.0 oz per 1000 ft^2 and above inhibited the growth of Penncross creeping bentgrass for four weeks. After four weeks the plants treated with the 1.0 and 2.0 oz rates started to recover, while the plants treated with the highest rate remained suppressed for the duration of the study. This type of recovery after 4 weeks did not occur with the one-leaf treated plants. This may indicate that as the bentgrass plants mature, they become more tolerant of Rubigan applications.

The results of single applications of Rubigan 50W on Pullman annual bluegrass plant growth at the one-leaf stage are illustrated in Figure 5. It can be seen that rates of 1.0 oz per 1000 ft^2 and above inhibited the shoot growth for the duration of the study. These results mirror those reported for the high rates of Rubigan on Penncross at the one-leaf stage of growth (Figure 3). The growth of the plants treated with the lower rates of 0.2 and 0.4 oz per 1000 ft^2 were less affected, and in fact did not differ significantly from the untreated plants six weeks after treatment.

At the four-leaf stage of growth, rates of 0.4 oz and above stunted the growth of Olympia annual bluegrass for four weeks (Figure 6). After four weeks, there was a general increase in growth of the plants treated at all rates. This response may indicate that as annual bluegrass matures, it is able to recover from Rubigan applications with time.

In addition to suppressing shoot growth, Rubigan applications also tend to decrease the root growth of creeping bentgrass and annual bluegrass. The effects of Rubigan on the root growth of bentgrass at the one-leaf growth stage are presented in Figure 7. It can be seen that all rates of Rubigan caused inhibition of root growth.

In fact, plants which received rates of above 0.4 oz showed very little root growth for the duration of the study.

At the four-leaf stage, root growth of Emerald creeping bentgrass was again suppressed by the high rates of application (Figure 8). While inhibition was complete at the 4.0-oz rate, slight increases in root growth by the 1.0- and 2.0-oz rates were seen six weeks after treatment. The low rates of 0.2 and 0.4 oz showed little effects of root suppression at the four-leaf stage of growth.

Applications of Rubigan also caused inhibition of root growth in annual bluegrass. As illustrated in Figure 9 for Olympia annual bluegrass at the one-leaf stage, rates of 1.0 oz and above inhibited root growth for the duration of the study, whereas the lower rates (0.2 and 0.4) caused less root inhibition. At the four-leaf stage (Figure 10), inhibition of root growth was present at rates above 0.4 oz, with the highest rate of 4.0 oz per 1000 ft^2 causing the greatest suppression. These results for decreased root growth in annual bluegrass are similar to those found for creeping bentgrass (Figures 7 and 8). This may indicate a decreased selectivity for Rubigan between creeping bentgrass and annual bluegrass and warrant further research.

CONCLUSIONS

Preliminary results of this study indicate that:

1. Rubigan applications inhibit the emergence/survivability of annual bluegrass and creeping bentgrass. The emergence/survivability of creeping bentgrass was sensitive to all rates of Rubigan application, whereas reductions of annual bluegrass emergence/survivability greater than 20 percent were only seen at the highest rates of application.

2. The growth of both annual bluegrass and creeping bentgrass were more susceptible to Rubigan applications at the one-leaf stage than at the four-leaf stage. Application rates also had an effect of the performance of each species. In general, the higher application rates of 1.0, 2.0, and 4.0 oz Rubigan 50W caused greater growth suppression than did the lower application rates of 0.2 and 0.4 oz. In this study, where only single applications of Rubigan were evaluated, the suppressions caused by the high rates of application may not present themselves if multiple applications of lesser rates were applied.

3. Root growth of both creeping bentgrass and the annual bluegrass was affected by Rubigan applications. Rates above 0.4 oz per 1000 ft^2 caused significant inhibition of root growth, while rates of 0.2 and 0.4 oz had a lesser effect.

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Figure 1. The Effects of Rubigan 50W on the Emergence of Penncross Creeping Bentgrass.

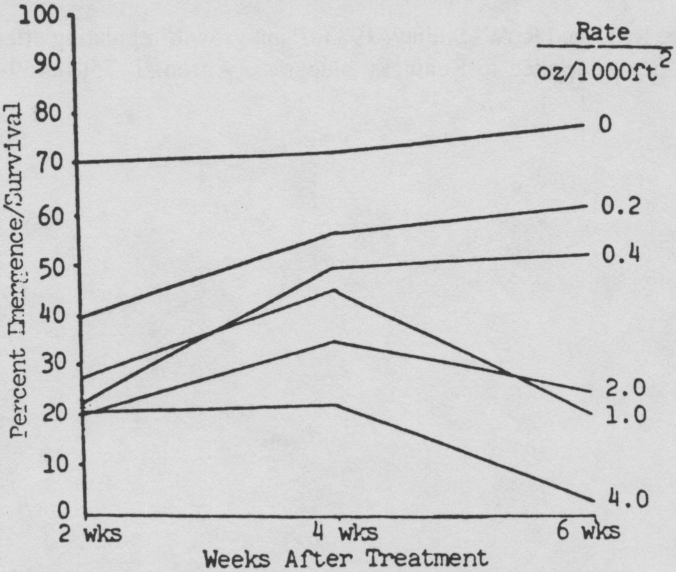


Figure 2. The Effects of Rubigan 50W on the Emergence of 'Olympia' Annual Bluegrass.

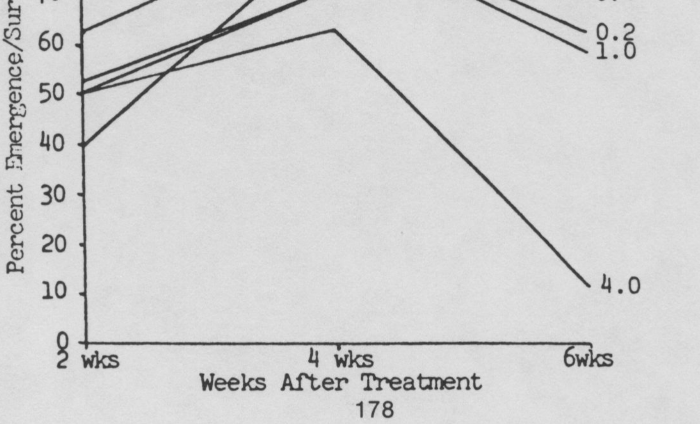


Figure 3. The Effects of Rubigan 50W on the Growth of Penncross Creeping Bentgrass at the One-Leaf Stage.

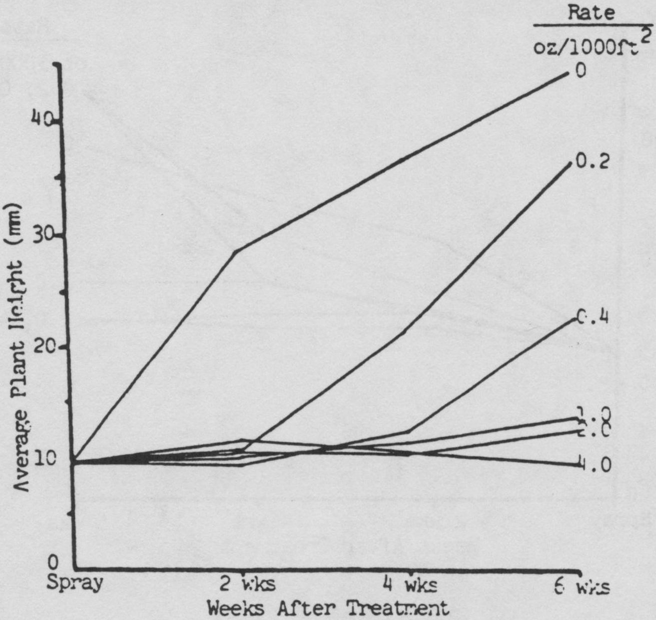


Figure 4. The Effects of Rubigan 50W on the Growth of Penncross Creeping Bentgrass at the Four-Leaf Stage.

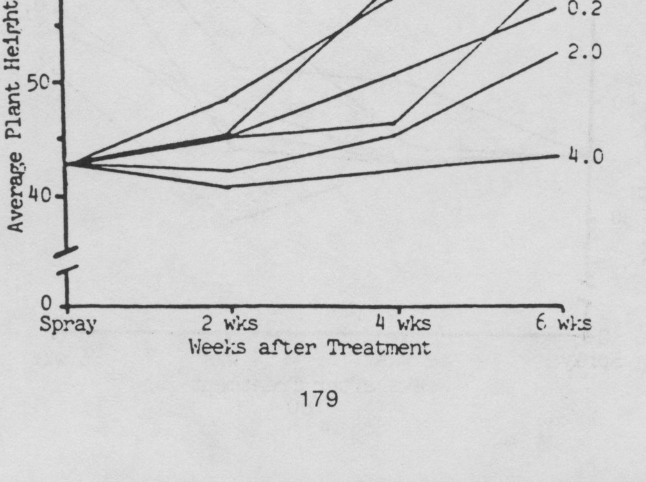


Figure 5. The Effects of Rubigan 50W on the Growth of 'Pullman' Annual Bluegrass at the One-Leaf Stage.

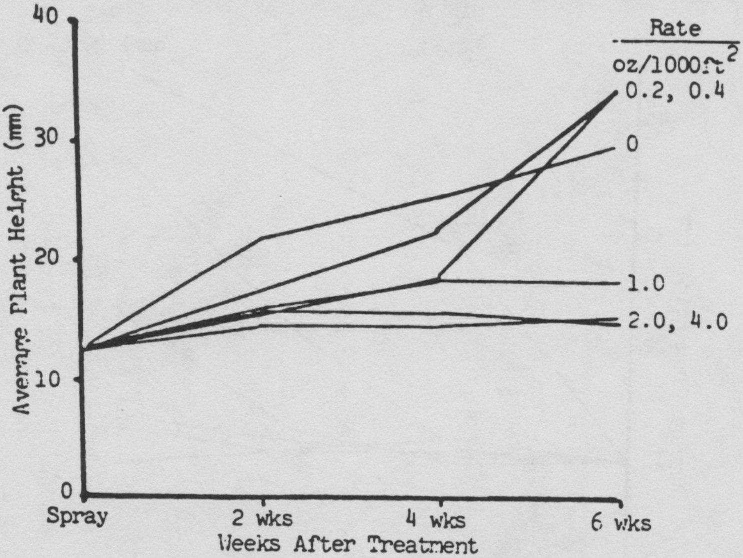


Figure 6. The Effects of Rubigan 50W on the Growth of 'Olympia' Annual Bluegrass at the Four-Leaf Stage.

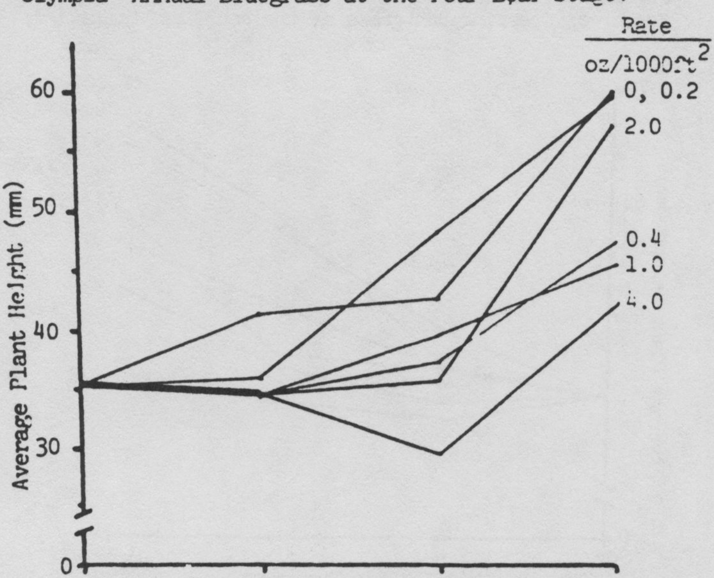


Figure 7. The Effects of Rubigan 50W on the Root Growth of Penncross Creeping Bentgrass at the One-Leaf Stage.

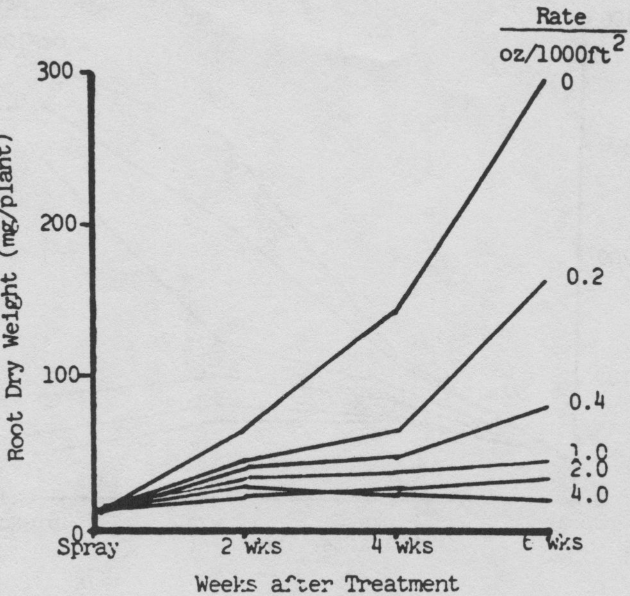


Figure 8. The Effects of Rubigan 50W on the Root Growth of Emerald Creeping Bentgrass at the Four-Leaf Stage.

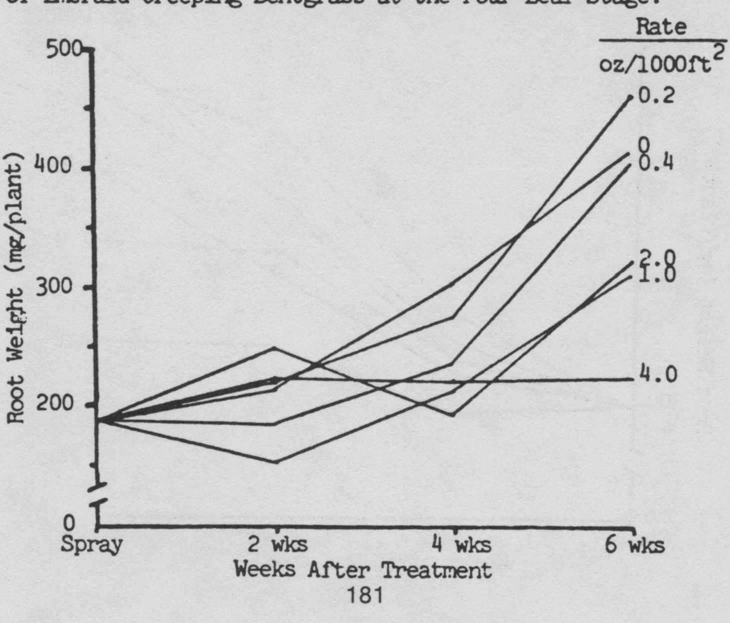


Figure 9. The Effects of Rubigan 50W on the Root Growth of 'Olympia' Annual Bluegrass at the One-Leaf Stage.

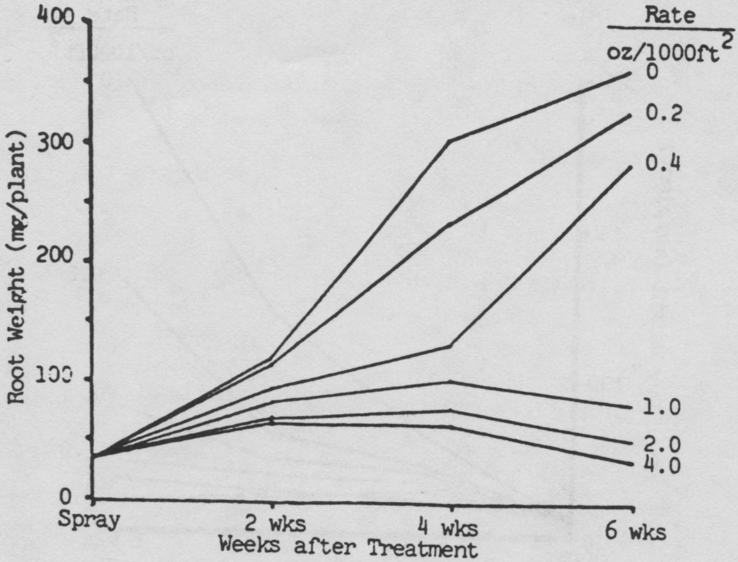
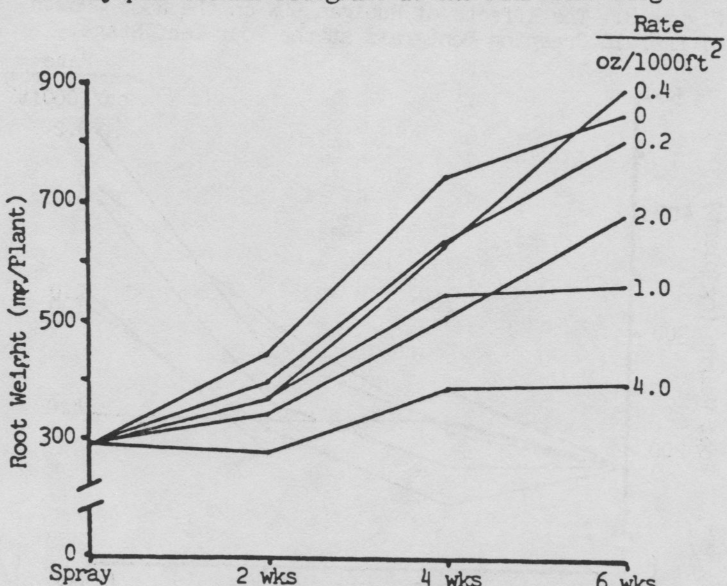


Figure 10. The Effects of Rubigan 50W on the Root Growth of 'Olympia' Annual Bluegrass at the Four-Leaf Stage.



AERIFICATION VERSUS SOIL COMPACTION AND THATCH DEVELOPMENT[1]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

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Turfgrass managers are developing a growing interest in the use of soil aeration in their cultural programs. Soil aeration covers practices like coring, shattercore (i.e. solid tine) aerating, slicing and spiking. Regardless of the procedure used, there are numerous benefits that can be derived from aerification. These benefits include: reduced soil compaction, enhanced thatch decomposition, enhanced depth and extent of turfgrass rooting, improved heat, drought and disease tolerance, and improved resiliency.

The procedures used to obtain these benefits are commonly referred to as soil aerating practices, but really are best described as soil cultivation practices since they influence more than just the properties of soil aeration.

Soil aeration refers to the naturally occurring process of air exchange between the soil atmosphere. Soil cultivation (i.e. coring, slicing, and spiking) refers to the mechanical process used to enhance soil aeration, percolation, infiltration and rooting. Soil cultivation procedures are used extensively to reduce problems associated with soil compaction on extensively used turfgrass sites. Core cultivation can also be used to effectively reduce, modify and manage thatch accumulation.

Soil compaction is extremely limiting to plant growth and development. Depth, extent and viability of turfgrass root growth are reduced with soil compaction. Large pore space decreases and small pores increase as does soil bulk density. These factors add to physical restrictions normally encountered by roots when growing in uncompacted soils. Soil oxygen levels, infiltration rates and percolation rates decrease as large pore spaces decline and bulk density increases. Turfgrass plants may respond to compaction with reduced vertical and lateral growth as well as restricted root growth. Compaction on turfgrass sites is generally most prevalent in the upper 1.0 to 1.5 inches of soil. Core cultivation can be used to reduce compaction and enhance turfgrass growth.

Thatch accumulation can be minimized by using proper cultural practices, turfgrass selection and soil management. It is not easily done since vigorous, well-adapted turfgrasses produce more organic matter than poorly adapted species and are more prone to thatch build-up. These grasses require extensive and careful management to reduce thatching tendency.

Core cultivation is not as effective as power raking for thatch removal, but it is very effective as a management tool to reduce the rate of accumulation and for modifying thatch physical properties. Soil coring enhances aeration, modifies temperature extremes, and improves soil moisture relations. These factors are important to ensure adequate microorganism activity which is critical for effective thatch decomposition. Core cultivation can also be used to modify physical properties of thatch. As soil cores are removed, they are scattered on the turf surface and allowed to break down, redistributing the soil throughout the thatch profile. The redistributed soil increases thatch bulk density, enhances moisture and nutrient retention, reduces temperature extreme fluctuations and introduces new microorganisms. Most turfgrasses growing on heavy clay or highly disturbed soils require annual cultivation to restrict thatch build-up.

SNOW MOLD IN PERENNIAL RYEGRASS AS AFFECTED BY CULTIVAR, CUTTING HEIGHT, AND POTASSIUM[1]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.

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INTRODUCTION

The snow mold organisms are a common problem on turfgrasses throughout the Pacific Northwest. The snow molds discussed in this research are pink snow mold or Fusarium patch, caused by the fungus *Fusarium nivale* (Fn) Ces. Micronectriella (Shaffn.), and gray snow mold, Typhula snow mold, caused by *Typhula incarnata* Lasch ex. Fries. Excellent reviews of the important characteristics of these organisms and some cultural and chemical methods of control have been made by other researchers (2,3,6,11,12).

The snow mold organisms occur on all major turfgrasses (2), and while there has been extensive work on bluegrass (*Poa pratensis*) and bentgrass (*Agrostis* spp.), there has been limited work conducted on the snow mold tolerance of the newer turftype perennial ryegrasses (*Lolium perenne*). Work on the cultural aspects of cutting height and potassium levels as they affect snow mold in perennial ryegrass is very limited. Therefore, this study was conducted to evaluate the effects of cutting height and potassium levels on several cultivars of perennial ryegrass.

MATERIALS AND METHODS

A mature turf of 14 cultivars of perennial ryegrass was used in this study. Throughout most of the year the turf was mowed at a cutting height of 1.5 inches and irrigated as needed to prevent stress. On approximately August 15 of 1983 and 1985, for the 1984 and 1986 tests, respectively, the turf was cut at 1.0, 2.0, or 3.0 inches. These cutting heights were maintained throughout the fall. Potassium was applied at 0, 2.0, 3.5, or 5.0 lb of K_20 as potassium sulfate in split applications during September and October 1983 and at 0 or 7 lb of K_20 in split applications during September and October of 1985. The soil was a Palouse silt loam with a pH of 5.6, % OM of 3.7, P (ppm) of 22.0, K (ppm) of 420, and Ca (meq/100 g) of 10.2. Since P was adequate to maintain turfgrass growth, no P (with one exception, see Table 1) was applied to the plots. Since 1982, nitrogen was applied to the turf at 3 to 4 lb of N per 1000 ft^2 primarily from ammonium sulfate. The N application for 1983 and 1985, the years prior to snow mold ratings are presented in Table 1. Plots were visually rated for snow mold several times per year. Early winter (January 31, 1985 and January 28, 1986) and early spring (April 15, 1984 and May 1, 1986), just prior to complete greenup but at a time when the snow mold spots were still distinct, rating will be presented.

The experimental design was a randomized complete block with 4 replications. The study was analyzed as a factorial with 14 cultivars, 3 cutting heights, and 4 levels of K_20 in the 1984 test and 2 levels of K_20 in the 1986 test, respectively. Means were separated using a protected LSD at the 5% level.

RESULTS AND DISCUSSION

Since there were few interactions in 1984 and none in 1986, only the main effects will be discussed in this paper. The main effects are the effect of perennial ryegrass cultivars, cutting height, and potassium level as they individually influenced the incidence of snow mold.

Are there differences among the perennial ryegrasses for snow mold tolerance? Work in Europe and Japan (7,8,10) and the preliminary results of this study would suggest that there are differences. The winter and spring snow mold ratings are presented in Tables 2 and 3, respectively. Since this is an ongoing study, final conclusions have not yet been drawn and, therefore, overall performance means have been omitted from the tables.

In looking at the data from Tables 2 and 3, we can observe that 1) there are differences among the cultivars, 2) there are differences between the response of the cultivars to rating period, i.e., winter ratings ranking of cultivars for snow mold tolerance is somewhat different from the spring rankings, and 3) there appears to be a difference in response from year to year, i.e., 1984 vs. 1986.

It should be noted that in this study, as in most studies involving numerous cultivars, there is considerable statistical overlap among the cultivars. The top ranked cultivar is generally not statistically different from those that rank several positions below it. This is the reason that cultivar evaluations need to be repeated for several years so that eventually the superior cultivars begin to appear at the top of the ranking. However, even after several years of evaluation, the top ranked cultivar may not be statistically superior from many others. This study will be continued for a minimum of one more year prior to giving a final ranking of cultivars.

The difference between the winter and spring ratings would indicate that some cultivars are very susceptible early in the winter but apparently do not incur much of an increase in now mold during the spring of the year. On the other hand, cultivars which have a good spring ranking could be those that begin spring growth early and thus the effects of snow mold are not as evident. A closer evaluation of which of these cases is true needs further study. The year-to-year variation in ranking may be explained in part by cultivar differences with regard to the particular snow mold organisms to which they are most susceptible. In 1984, visual observations indicated that the predominant snow mold occurring on the turf was *Fusarium nivale*, while in 1986 there was approximately a 50:50 infection of the turf with *Fusarium nivale* and *Typhula incarnata*.

The effect of cutting height on the incidence of snow mold is presented in Table 4. In nearly all cases when the cutting height was increased the incidence of snow mold increased. This increase in snow mold was very consistent from rating to rating and from year to year. It would appear that unlike the incidence of disease on many other turfgrass species where there is more disease on close-cut grass (1,9), in perennial ryegrass, there is less disease in close cut turf. As stated by Gould (6), a grass that is mowed at the proper height of cut is often more resistant to disease than when it is maintained at a higher height of cut. Gould thought that the excess foliage of the higher cut turf provided an excellent environment for the development and spread of the disease organisms and that the accumulation of excessive foliage provided an abundant food source for the disease organism when the turf began to decompose during the winter.

This work would indicate that perennial ryegrass should be cut at the lowest proper mowing height going into the winter and that excessive foliage should not be allowed to accumulate between the last fall mowing and the onset of winter when turfgrass top growth ceases. However, Gray and Copeman (7) have reported more snow mold on late cut grasses in Scotland. Additional research is needed in this area.

The effect of potassium level of snow mold is given in Table 5. This work indicates that potassium increased the amount of snow mold observed in the turf during 1984 and 1986. This is contrary to what most studies on disease have shown (4). In general, the application of potassium has been highly touted in the management of turfgrasses for stress tolerance. Potassium has been observed to improve drought tolerance, cold tolerance, heat tolerance, and disease tolerance in plants.

This seeming contradiction of the turfgrass literature with regard to the effect of potassium in mitigating turfgrass diseases is similar to work reported previously by Goss and Gould (5). They found, in their work on the relationships between fertility levels and Fusarium patch on colonial bentgrass (*Agrostis tenuis*), that plots which received no applications of P and relatively low N (6 lb N per 1000 ft^2) there were more disease spots at 0 K than at 8 lb of K per 1000 ft^2. In their study, as was the case of the present study, soil tests indicated adequate P for good turf growth. However, Goss and Gould reported that if they applied 4 lb of P per 1000 ft^2, the number of disease spots decreased markedly with increasing levels of K. Results of this study, in light of previous experiment by Goss and Gould (5), would indicate that the relationship between P and K with regard to disease susceptibility of turfgrasses warrants further investigation.

CONCLUSIONS

The preliminary results of this study are:

1. There are differences among the turftype perennial ryegrasses for snow mold injury. However, only following additional testing can the most tolerant cultivars for the snow mold conditions of the Pacific Northwest be recommended.

2. The incidence of snow mold was most severe as the cutting height was increased during fall mowing.

3. Fall applications of potassium did not mitigate the incidence of snow mold disease and actually enhanced it under the fertility conditions of this study.

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Table 1. Fertilizer applications during the fall.

1983	1985
Apr 83 1 lb N as Urea	Apr 85 1 lb N as ANS
Jun 83 1 lb N as ANS	Jun 85 1 lb N as 16-25-8
Aug 83 1 lb N as ANS	Aug 85 1 lb N as ANS
Oct 83 1 lb N as ANS	

ANS = Ammonium sulfate.

Table 2. Effect of perennial ryegrass cultivars on snow mold (winter ratings).

Cultivar	1-31-84	1-28-86	Mean	Cultivar	1-31-84	1-28-84	Mean
Diplomat	4.8 cd	3.2 e	4.0	Blazer	5.0 cd	4.7 abcd	4.8
Sprinter	4.6 d	3.6 de	4.1	Perfect	5.4 abcd	4.4 abcd	4.9
Manhattan	4.2 d	4.3 bcde	4.3	All*Star	6.2 ab	3.7 de	5.0
Citation	4.7 cd	4.2 cde	4.4	Fiesta	5.0 bcd	4.9 abc	5.0
Caravelle	5.0 bcd	4.1 cde	4.6	Regal	4.7 cd	5.5 a	5.1
Loretta	4.8 cd	4.5 abcd	4.7	Dasher	4.8 cd	5.4 ab	5.1
Score	5.9 abc	3.7 de	4.8	Acclaim	6.4 a	4.4 abcde	5.4

Rated 1 to 9; 1 = none.

Table 3. Effect of perennial ryegrass cultivars on snow mold (spring ratings).

Cultivar	4-15-84	5-1-86	Mean	Cultivar	4-15-84	5-1-86	Mean
Citation	1.6 e	1.3 f	1.4	Acclaim	2.4 ab	2.1 cdef	2.2
All*Star	1.5 e	1.5 ef	1.5	Blazer	2.4 ab	2.3 cdef	2.4
Loretta	1.5 e	1.5 ef	1.5	Sprinter	1.7 de	3.1 abcd	2.4
Regal	1.7 de	2.1 def	1.9	Score	2.6 a	2.5 bcde	2.6
Dasher	1.9 cde	2.2 cdef	2.0	Manhattan	2.0 cd	3.4 abc	2.7
Fiesta	2.1 bc	2.2 cdef	2.1	Perfect	2.4 ab	3.6 ab	3.0
Diplomat	2.5 a	2.0 def	2.2	Caravelle	2.5 a	4.3 a	3.4

4-15-84 rated 1 to 4; 1 = none.
5-1-86 rated 1 to 9; 1 = none.

Table 4. Effect of cutting height on snow mold.

Cutting height (inches)	Rating date 1-31-84	4-15-84	1-28-86	5-1-86
1	4.4 c	1.3 c	2.9 c	1.6 b
2	5.4 b	2.1 b	4.4 b	2.7 a
3	5.6 a	2.7 a	5.7 a	3.0 a

Rated 1 to 9; 1 = none except 4-15-84 rated 1 to 4; 1 = none.

Table 5. Effect of potassium level on snow mold.

K_2O/ 1000 ft²	Rating date 1-31-84	4-15-84	1-28-86	5-1-86
0	4.9 b	1.9 b	4.2 b	2.6 a
2.0	5.1 a	2.1 a	——	——
3.5	5.3 a	2.2 a	——	——
5.0	5.2 a	2.1 a	——	——
7.0	——	——	4.5 a	2.3 b

Rated 1 to 9; 1 = none except 4-15-84 rated 1 to 4; 1 = none.

NEWER PRE-EMERGENCE CHEMICALS FOR POA ANNUA CONTROL[1]

Stanton E. Brauen[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
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Annual bluegrass (*Poa annua*), is the most common turfgrass west of the Cascade Mountains. As all turf people know, it is blessed, revelled, adorned, loved, cussed and despised. Many would prefer research efforts be devoted to making it a better grass than it is. That is, to improve its rooting depth, longevity, density and reduce its susceptibility to disease and stress while controlling the unsightly seedhead exposure common in closely mowed turf. The United States Golf Association sponsored research in annual bluegrass variety development, under the direction of Dr. Donald White in the Department of Horticultural Science at the University of Minnesota, hopefully will be helpful in producing annual bluegrass varieties with some or all of these characteristics. While this program develops, other researchers in public and private agencies are looking for ways to reduce annual bluegrass in commonly used domestic turfgrasses. Several studies are under investigation at Puyallup and elsewhere. This is a brief report of first year observations at Puyallup, in studies with prodiamine herbicide.

The two current studies were begun in the fall of 1985 and in the spring of 1986. One study is to evaluate the persistence of prodiamine preemergence herbicide in the soil and to assess the effect of that persistence on the establishment of common turfgrass species in an overseeding program. This study is not being reported at this time. The second series of studies is to evaluate the effect of sequential applications of prodiamine preemergence herbicide on turfgrass quality, density, and rooting of four common turf species and annual bluegrass composition therein.

The sequential applications are being applied to five turfs consisting of fine fescue, Kentucky bluegrass, colonial bentgrass and perennial ryegrass. In addition, applications (at the initiation of the trials) were made to established and very young perennial ryegrass turfs. Prodiamine is applied in the fall, or spring, or both fall and spring. Rates of prodiamine are 1, 2 and 4 lb a.i./acre. Bensulide at 12 lb a.i./acre fall and 6 lb a.i./acre spring, DCPA at 12 lb a.i./acre fall and spring, pendimethalin at 1.5 lb a.i./acre fall and spring, cinmethylin at 1 lb a.i./acre fall and spring and a non-treated control are included.

All treatments are applied with a bicycle single wheeled CO2 sprayer at 25 psi manifold pressure with 8003LP nozzles in 86 gal water per acre. Plots are irrigated within 24 hours following application if adequate rainfall has not occurred. Plots are evaluated periodically for turf injury, percent cover, turf density, root mass, and percent annual bluegrass composition.

Figure 1 illustrates the overall main effect of prodiamine rate on average turfgrass injury when applied in the spring and fall to all species included in the 5 studies. Prodiamine when applied at 1, 2 or 4 lb a.i./acre once in the fall and once in the spring caused turfgrass injury. However, Figure 2 shows that the turfgrass injury, which was observed in July, was very low in Kentucky bluegrass sod and most severe in fine fescue. The colonial bentgrass turf was injured to a lesser extent than fine fescue but the new perennial ryegrass was injured nearly as much as fine fescue. In the fine fescue turf, injured turf was reinvaded by bentgrass, while in the new perennial ryegrass turf, no species invaded the bare areas. Older perennial ryegrass (data not graphed in Figure 2) showed very little injury to prodiamine.

DCPA injured fine fescue and bentgrass turfs very severely while Kentucky bluegrass turf and perennial ryegrass received little injury. Bensulide and pendimethalin showed no injury to any species in July (Figure 3). Where prodiamine was applied only in the spring at 1 lb a.i./acre, no injury occurred to any species, but when the rate was increased to 2 or 4 lb a.i./acre injury did occur (data not shown). The least injury was observed with perennial ryegrass in the spring application. Similar injury trends occurred with the fall application except young perennial ryegrass was injured extensively at 2 and 4 lb a.i./acre.

In July, root mass was estimated for each of the treatments (Figure 4). Prodiamine applied in the fall and spring at 1 lb a.i./acre did not appear to reduce total average root mass of the four species in the top three inches of the root zone; however, significant decreases in root mass did occur when prodiamine was applied at 2 and 4 lb a.i./acre. Likewise, when prodiamine was applied only in the spring or only in the fall, root mass was reduced at the 2 and 4 lb a.i./acre rate as compared to no herbicide application. Bensulide and DCPA reduced root mass when measured over all species while no reduction in root mass could be detected in plots treated with pendimethalin or cinmethylin.

Annual bluegrass was reduced by all herbicide treatments (Figure 5). Application of prodiamine applied in the fall and spring was most effective in reducing and nearly eliminating annual bluegrass from the test plots. However, applications of prodiamine at 1, 2 and 4 lb a.i./acre in the fall or spring and any of the applications of bensulide, pendimethalin and cinmethylin reduced annual bluegrass presence in all turf. DCPA increased annual bluegrass in the first season (data not shown).

The preliminary data suggest prodiamine is effective as a control for annual bluegrass in turf in western Washington. Young turfgrass is much more sensitive to injury than established turfgrasses and turfgrasses should be at least six months old prior to prodiamine application if 1 lb a.i./acre or more is applied. Fine fescue seems to most easily injured followed by colonial bentgrass. Perennial ryegrass and Kentucky bluegrass appear least sensitive to injury.

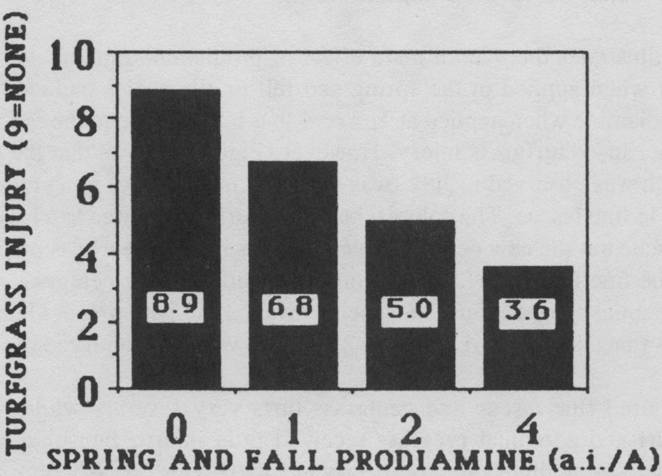

Figure 1. Effect of prodiamine application in the spring and fall on average turfgrass injury of four species.

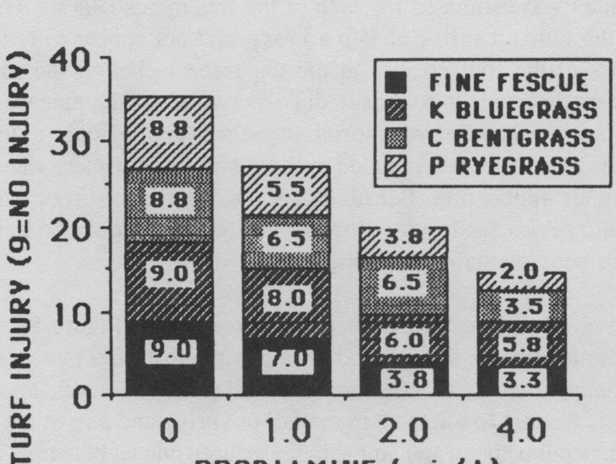

Figure 2. Effect of prodiamine on injury of fine fescue, Kentucky bluegrass, colonial bentgrass, and perennial ryegrass following spring and fall application.

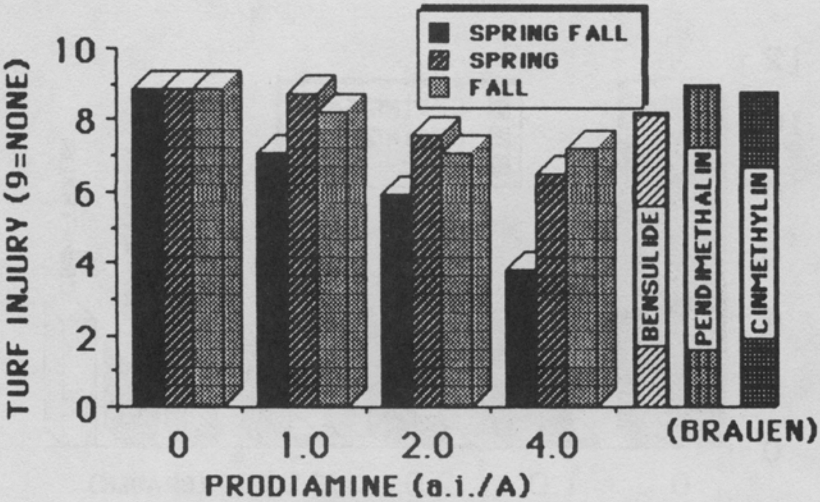

Figure 3. Effect of prodiamine late summer average turfgrass injury of four species following application during fall and spring, fall and spring only.

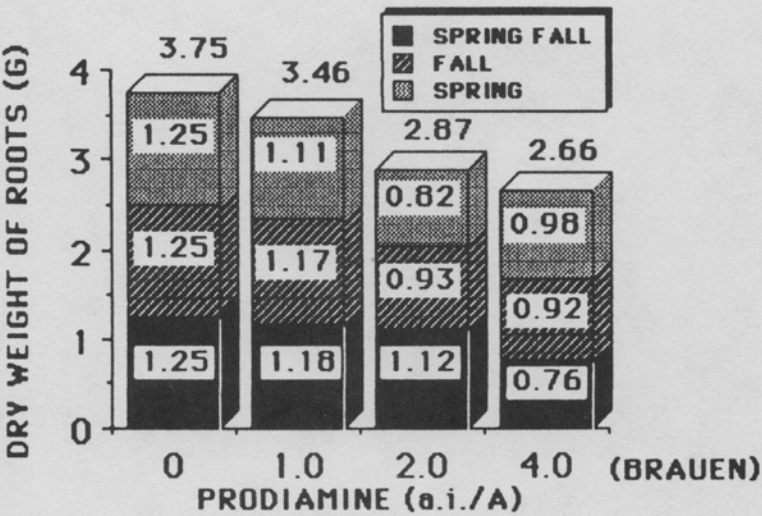

Figure 4. Effect of prodiamine on dry weight root mass of four species following application during fall and spring, fall only or spring only.

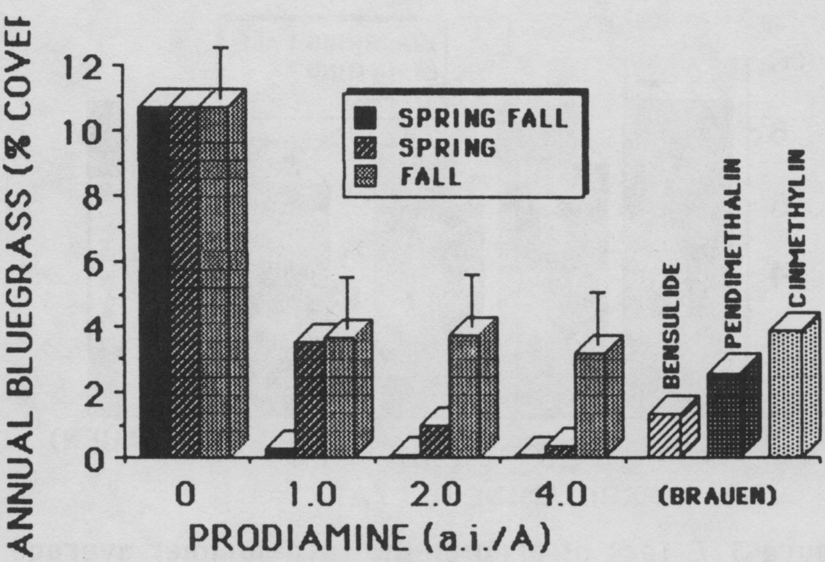

Figure 5. Effect of prodiamine on annual bluegrass cover in four species following application during fall and spring, fall only and spring only.

NECROTIC RING SPOT RESEARCH UPDATE[1]

Gary A Chastagner[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Associate Plant Pathologist, Western Washington Research and Extension Center (WSU), Puyallup, WA.

Necrotic ring spot, caused by *Leptosphaeria korrae*, is causing severe damage to bluegrass turf in the Pacific Northwest. Although the disease can occur on turf established by seeding, most of the affected turf was established as sod and initial symptoms generally appeared 1 to 3 years after establishment. Observations in the midwest and northeast indicate the disease is present in the sod at the time of lifting. Symptoms appear in late spring or early summer as chlorotic spots or patches with a thinning and/or dying of the grass. Infected turf is easily lifted from the soil and both the roots and shoots of these plants eventually die. Donut-shaped rings or patches from several inches to 1-2 feet in diameter are formed as symptoms develop and active rings have margins which are a light reddish-brown in color. The centers of rings are usually invaded by broadleaf weeds and grasses.

During the past three years our research on necrotic ring spot has focused on characterization of the pathogen, comparing the pathogenicity of *L. korrae* isolates from Washington to isolates from other states, reproducing disease symptoms under field conditions by inoculating turf, and evaluating fungicides for control of this disease.

These studies have shown that there is considerable variability in the pathogenicity of isolates of *L. korrae*. Virulent isolates of *L. korrae* from Washington have been identified and will be used in future tests to determine the susceptibility of turfgrass cultivars to this disease. Initial symptoms of necrotic ring spot appeared on inoculated Baron bluegrass turf in western and eastern Washington two years after inoculation and there was no difference in the appearance of symptoms on turf that was established using sod versus seed.

Our research has shown that necrotic ring spot can be controlled using fungicides. Applications of Rubigan, Banner, Spotless, and Fungo in the spring have controlled necrotic ringspot development during late summer and fall (Table 1). Our research also indicates that effective control of this disease requires yearly applications of these fungicides.

The development of longterm methods in controlling this disease is dependent upon obtaining additional information about the biology of *L. korrae* and the epidemiology of this disease. In addition, obtaining information on the susceptibility of turfgrass cultivars to this disease under field conditions is needed.

Greenhouse studies have indicated there are differences in susceptibility between turfgrass species and between cultivars within a given species. Limited information, however, is available regarding the susceptibility of turfgrass species and cultivars to this disease under field conditions. Identification of turfgrass species with resistance to this disease would enable turf managers to obtain longterm control of this disease by using cultivars with resistance at the time of establishment and in overseeding programs.

Table 1. Effect of April 24, 1986 applications of fungicides on the incidence and severity of Necrotic Ring Spot on September 11, 1986.

Treatments[a]	Rate oz ai/1000 ft²	Number of reps/5 with disease	Average number of patches/plot	Average percentage plot area w/disease
Check	-	5	5.6	13.2
Tersan 1991 50W	2.0	5	5.0	19.4
Fungo 50W	2.0	5	2.4	3.0
Systhane 40W	1.0	3	1.8	2.8
Banner 1.1EC	1.0	4	2.4	4.0
Rubigan AS	0.5	3	1.0	1.0
Rubigan AS	1.0	0	0.0	0.0
Spotless 25W	1.0	0	0.0	0.0
		LSD (P = 0.05)	2.01	7.31

[a] Treatments were applied in the equivalent of two gallons of water plus 0.3202 X-77 per 1000 ft². The plot was a completely randomized design with five 10 ft x 10 ft replications per treatment.

CHARACTERISTICS AND USES FOR WILDFLOWERS IN LANDSCAPE[1]

Crystal Fricker[2]

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[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Pure Seed Testing Inc., Hubbard, OR.

For the past four years we have been evaluating approximately 250 species of wildflowers and ornamental grasses for appearance and seed production in the Willamette Valley of Oregon. This discussion will cover some of the characteristics observed in our trials which should be considered when using wildflowers in landscapes.

Wildflowers are a colorful way to brighten up areas while requiring little maintenance once established. The uses of wildflowers include enhancing the deep rough areas of golf courses, the beautification of parks and other public facilities, erosion control while adding variety to roadsides, to cover difficult-to-mow areas and for the landscaping of homes.

MANAGEMENT TECHNIQUES

There are several different management schemes to choose when growing wildflowers. A mixture containing all annual species can be planted and reseeded yearly, producing a broad range of colors and textures. After flowering is completed they can be mowed and Round-up can be used to control weeds before reseeding each spring.

Annuals and perennials can be used together, achieving color with the annuals flowering the first summer after a spring planting. Cold winter temperatures vernalize the perennials so they initiate flowers the following spring, a year after planting. Herbicides can be used prior to the initial planting for weed control. After the annual species die, the bare areas will be open to weed invasion, so they should be reseeded with more annuals each spring until the perennials take over.

A third possibility would be to seed an all perennial mix in the spring or fall. If planted in the spring, only a few flowers will be evident until the winter temperatures vernalize the plants. At this time herbicides can only be used before planting, followed by hand weeding for the life of the stand. Nonaggressive bunchgrasses can also be used in mixtures for soil stabilization to fill in areas where annual flowers die out.

Mixtures of wildflowers and grasses are another possibility. A bunchgrass such as sheeps fescue adds a blue-gray color to the foliage and can be helpful to compete with weeds, while not crowding out the flowers. Other grasses which could be used in wildflower mixes are tall fescue, hard fescue and native grasses such as blue grama, buffalograss or big bluestem. Again, hand weeding must be used after planting. In a landscape situation individual species may also be used by planting complimentary colors, heights, and flowering times where desired.

Unique seed types tend to make some species of flowers interesting as well as colorful. The seed clusters of the pincushion flower, the seed pod of the flutter mill, and the two different shaped seeds of the African daisy (*Dimorphotheca sinuata*) all resemble their names.

Differing shapes and sizes of flower seeds make a difference as to what proportion is used of each species in a mix. There are several characteristic groupings of flowers which can be used for different effects. Short and tall groups of both annuals and perennials can be put together as well as certain colors and flowering periods.

WEED CONTROL

Controlling weeds is a major factor to having successful wildflower areas. Fumigation can be used in all of the above cases but can be expensive. Soil and crop histories can also be used to determine less weedy areas to plant in. For instance, on a golf course a section of sod could be removed for a relatively weed-free area to plant flowers. Research is underway to develop preemergent and postemergent herbicide programs to control weeds during the life of the flower stand. Widespread national testing of wildflower mixtures tolerant to several preemergent herbicides is currently in progress.

HEIGHT GROUPS

The heights of short flowers can range from 6 inches to 16 inches when flowering. African daisy, catchfly, forget-me-not, California poppy, spurred snapdragon and maiden pinks are a few examples.

Tall groups of flowers can range from 2 to 4-1/2 feet in height including such annuals and perennials as bachelor buttons, black-eyed Susan, plains coreopsis, gaillardia, lupines, purple coneflower and others. When short flowers are mixed with tall ones, they tend to be crowded out and stunted by the shade, thus not showing up enough to be of any significance.

FLOWERING PERIODS

Flowering periods are critical to maintaining a wide range of flowers for an extended period of time. Some species produce flowers for up to 90 days depending on water availability, and others produce flowers for only 19 days, with most flowers lasting 30 to 40 days. The flowering periods of 100 species have been charted for annual and perennial classifications. Tables will be presented showing the variation between species for early and late flowering during each season. A few early flowering species are blue bells, babys breath, sweet alyssum, Johnny-jump-up, Iceland poppy and forget-me-not; while New England aster, purple coneflower, prairie coneflower, mountain phlox, and rocket larkspur produce flowers during late summer and early fall.

AGGRESSIVE TYPES

Wildflowers to avoid in mixtures or reduce in proportion would be those which are very aggressive. These flowers would do well in difficult areas as they are quite vigorous, but in a mixture they could take over if used at a high percentage. Chicory, yarrow, butter and eggs, ox-eye daisy, snow-in-summer, and cosmos would fit in this category.

COLORS

Colors can also be used to group flowers with the warm colors of coreopsis, African daisy, Siberian wallflower, scarlet flax, Iceland poppy, yellow prairie coneflower fitting together, and the cool colors of blue bells, columbines, globe gilia, blue flax, dames rocket, and catchfly forming a separate distinctive group.

SELF RESEEDING ANNUALS

When using annuals in mixes it is advantageous to use those which reseed themselves each year. A few examples that have been noted in our trials are bird's-eyes, farewell-to-spring, tidy tips, mountain phlox, and bachelor buttons. Also, if you must plant in the fall, there are annuals which survived the winter near Hubbard, Oregon. These would include corn poppy, garland chrysanthemum, plains coreopsis, catchfly and others.

EMERGENCE

Emergence can be an important quality to consider when planting wildflowers, the faster emerging flowers being plains coreopsis, bachelor button, corn poppy, yarrow and blue flax. Blazing star, purple coneflower, New England aster and rocket larkspur are slow to emerge.

DISEASES AND INSECTS

Problems to watch out for are diseases such as root rots, powdery mildew, downy mildew, and yellow virus on mature plants and damping off during the seedling stage. These diseases have been occurring in our trials and fields on perennial lupine, bachelor button, Iceland poppy, sweet pea, black-eyed Susan, purple coneflower, and African daisy thus far.

Cucumber beetles thrive on wildflowers and can damage their aesthetic value by eating the flower petals on a large number of species. Painted daisy and candytuft are their favorites. The diamondback moth has been found on dames rocket and Siberian wallflower, but is not a serious problem.

The above discussion covers traits such as color, height, flowering period, aggressiveness, reseeding ability and emergence, all of which should be considered when selecting wildflowers for landscaping to achieve the best results. Management preferences and weed control also make a difference as to which species to use.

Wildflowers are an interesting new touch which may fit into your particular situation. If so, give them a try and see what a difference they can make.

TABLE 1

1985 FLOWERING PERIOD OF ANNUAL WILDFLOWERS
PLANTED APRIL 15, 1985 NEAR HUBBARD, OREGON

	JUNE	JULY	AUG	SEPT	OCT
Dimorphotheca sinuata AFRICAN DAISY	********				
Chrysanthemum carinatum PAINTED DAISY	********				
Gaillardia pulchella INDIAN BLANKET		**********			
Delphinium ajacis - Blue ROCKET LARKSPUR		*************			
Clarkia unguiculata MOUNTAIN GARLAND	*******				
Gypsophilia murialis ANNUAL BABY'S BREATH	******				
Eschscholzia caespitosa DWARF CALIFORNIA POPPY	********				
Lavatera trimestris MALLOW		*******			
Gilia tricolor BIRDS EYES	*******				
Linum grandiflorum rubum SCARLET FLAX	********				
Gilila capitata GLOBE GILIA	********				
Gypsophilia elegans BABY'S BREATH	*******				
Clarkia amoena - tall single FAREWELL-TO-SPRING		*************			
Nemophila menziesii BABY BLUE EYES	*******				
Centaurea cyanus CORNFLOWER	***********				

TABLE 1 - continued

	JUNE	JULY	AUG	SEPT	OCT
Gilialeptantha purpusii SHOWY BLUE GILA	*****	***			
Phacelia campanularia BLUE BELLS	*******	**			
Linanthus grandiflorus MOUNTAIN PHLOX		*******	******	*******	
Linaria maroccana TOAD FLAX (N. Lights)	*****	**			
Silene armeria CATCHFLY	****	***			
Chrysanthemum coronarium - tall GARLAND CHRYSANTHEMUM	****	*******			
Iberis umbellata CANDY TUFT	****	**			
Coreopsis tinctoria PLAINS COREOPSIS		*******	**		
Dimorphotheca aurantiaca AFRICAN DAISY	*****	***			
Papaver rhoeas CORN POPPY		****			
Layia platyglossa TIDY TIPS	*****	**			
Lupinus succulentus ARROYO LUPINE	*******				
Lupinus benthamii BENTHAM'S LUPINE	*****	******			
Dimorphotheca pluvialis WHITE AFRICAN DAISY	*****	***			
Mentzelia lindleyi BLAZING STAR	****	*******	*		
Collinsia heterophylla CHINESE HOUSES	****	**			
Lobularia maritima - dwarf white DWARF WHITE SWEET ALYSSUM	*******	****			

TABLE 2

FLOWERING PERIODS OF PERENNIAL WILDFLOWERS
PLANTED APRIL 15, 1985 NEAR HUBBARD, OREGON

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***   = 1985 flowering period after spring planting.
---   = 1986 flowering period after winter vernalization.
---+  = Still flowering as of June 19th.

                           MAR  APR  MAY  JUNE  JULY  AUG  SEPT  OCT  NOV

Oenothera missouriensis                ------+     ************
  MISSOURI PRIMROSE

Linaria vulgaris                                   *************
  BUTTER AND EGGS

Viola cornuta                 ----------------+
  JOHNNY JUMP-UP                            ******************

Dianthus barbatus                     -------+
  SWEET WILLIAMS PINKS

Cheiranthus cheiri             ----------
  WALLFLOWER

Linum perenne lewisii              -----------+    ******
  BLUE FLAX

Lupinus perennis                   -----------     ******
  PERENNIAL LUPINE

Gaillardia aristata                    ------+          ************
  PERENNIAL GAILLARDIA

Coreopsis lanceolata                      ---+     **********
  LANCE-LEAVED COREOPSIS

Hesperis matronalis - violet       ---------
  DAMES ROCKET

Aquilegia vulgaris               -------
  DWARF COLUMBINE

Dianthus deltoides                 -----------+                  *****
  MAIDEN PINKS

Ratiba columnifera                          -+               *******
  PRAIRIE CONEFLOWER

Rudebeckia hirta                          ----+    ************
  BLACK-EYED SUSAN
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TABLE 2 - continued

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                            MAR  APR   MAY  JUNE  JULY  AUG  SEPT  OCT  NOV

Achillea millefolium                    ------+    **************
  WHITE YARROW

Cerastium biebersteinii           ------------
  SNOW-IN-SUMMER

Penstemon strictus                      ------+
  PENSTEMON

Papaveer nudicaule            ----------------+  ****
  ICELAND POPPY

Chrysanthemum leucanthemum         -----------
  OX-EYE DAISY

Myosotis palustris                 ------------+
  TRUE MARSH FORGET-ME-NOT                  ********

Echinacea purpurea                         ---+                   ******
  PURPLE CONEFLOWER

Machaeranthera tanacetifolia                     ****
  PRAIRIE ASTER

Aurinia saxatilis                   ----------


Lathyrus latifolius                        ---+         ********
  SWEET PEA

Thymus serpyllum                                       *************
  WILD THYME

Aster novea-angliae                                           *******
  NEW ENGLAND ASTER

Digitalis purpurea                     -------+
  FOXGLOVE

Lupinus vallicola                      -------+    *************
  VALLEY LUPINE

Penstemon palmeri                         --+
  PALMER PENSTEMON

Cheiranthus allionii          --------------  ****************
  WALLFLOWER

Myosotis sylvatica alpestris  ----------
  FORGET-ME-NOT
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SOME PRACTICAL TIPS ON PRUNING SHRUBS[1]

Tom Cook[2]

[1] Presented at the 40th Northwest Turfgrass Conference, Red Lion Inn, Pasco, WA, September 23-25, 1986.
[2] Department of Horticulture, Oregon State University, Corvallis, OR.

Pruning has always been a popular topic for authors in the horticulture field. Every year new books appear on the shelves and if you are like me, you probably buy your fair share of them. Most of these books vary more in layout and graphics than they do in content. Nearly every pruning book I have ever looked at approaches the subject in what I call the "classic style". The central theme for all of these books is that there is an optimum time and an optimum way to prune each different plant. If you understand the plant and prune it in a timely and horticulturally correct manner, you will be rewarded with a plant that looks great and flowers prolifically.

The correct way and time to prune flowering and ornamental shrubs is often divided into the following categories.

1. *Plants flowering on current year growth*. In this case, pruning is done in spring just as new growth is starting. The idea is to stimulate lots of new growth which will produce terminal flowers during early to mid-summer. Hybrid tea roses fit this category very nicely. The actual method varies from plant to plant and is generally detailed in the encyclopedia which should make up the bulk of a good pruning book.

2. *Plants flowering on old growth*. Plants in this group generally flower early in spring then grow vigorously through summer and set new flower buds by fall. Overwintered buds flower when spring arrives. These plants are best pruned as soon as they finish flowering so they will have time to put on new growth and set flower buds for next year.

A variation on this involves plants that flower on spurs. Spurs are simply short shoots which grow slightly each year and then set fruit buds. Since spur shoots are often persistent and generally look different than vegetative shoots, this group is often listed separately in pruning guidelines.

In both cases, buds produced one year flower the next so the actual differences in flower habit aren't significant. Forsythia is a classic shrub fitting this category. Flowering crabapples is an example of a tree that flowers primarily from spurs.

3. *Plants grown for special effects*. In this case, the goal is to prune to accentu-

ate a quality such as twig color. Red twig dogwood or purple smoketree are good examples of this. Left alone, the red twig dogwood is a cluttered mass on branches with a hint of red near the branch tips. Pruned back hard each spring, it responds by producing long straight branches with intense red color.

In addition to the categories just discussed, most pruning books contain a section on natural pruning as opposed to shearing. Most authors prefer natural style pruning because it accentuates the best features the plant has to offer. A typical discussion of natural pruning encourages use of thinning cuts where entire branches are removed at the point of origin. Shearing uses heading cuts where branches are cut indiscriminately in an attempt to shape or control the size of a plant.

Properly and skillfully done, natural pruning will leave you with a plant that just fits its space and shows little or no sign it has been pruned. Shearing is viewed as destroying natural form and ruining plant appearance.

The contrast between these two styles can be readily illustrated with junipers. Junipers by nature are irregular in growth and come in a multitude of colors and forms. Pruned naturally, they retain this delightful variation. Sheared, they all look like boxes or pompoms. Advocates of natural pruning have been known to get physically ill while walking in a neighborhood where junipers have been sheared.

Most pruning books also have a section on formal pruning. In it, they illustrate shearing techniques and tell how they can be used to create hedges or topiary. Often, they include pictures from great British gardens showing miles of hedges framing acres of beautiful gardens. The emphasis is on how hedges can help screen out defined garden areas and thus enhance the beauty of all of your naturally pruned specimen plants. In this, semi-formal pruning yields a backdrop for other plants via hedges or creates a focal point via topiary which is supported by the rest of the plantings.

PROBLEMS

With all of the good advice offered in these many books, why are there so many butchered plants in the landscape? Why is it the inevitable fate of all plants to get sheared? Could it be nobody needs these books or is it that nobody understands what they have read? Believe it or not, I have given a great deal of thought to these questions and come up with some ideas I feel might help solve the problem.

It all starts with perspective! Pruning books invariably base all recommendations on the needs of the plant. The authors assume we will prune our plants when the plants need to be pruned and in the way they need to be pruned. Most people prune when they can fit it into their schedule. Also, most people are goal oriented pruners. They have a specific goal such as keeping the juniper branches off the sidewalk or raising the crown of a tree to a specific height. In these cases, the offending branches are simply obstacles to be removed. Their vision is not of the plant but of the sidewalk. Their perspective is different.

Another problem is our tendency to be reactionary pruners. We wait until it is too late, and then react by butchering or shearing because we don't know what else to do. That twig which could have been snipped off with our handshears three years ago is not a 4-inch branch and has ruined the shape of the plant. We missed our chance to prune gracefully. If we pruned our plants annually, we could control their growth very nicely. Unfortunately, we often forget about them until they get in the way, then we react.

At the commercial level, the two factors affecting pruning practices are lack of control and labor costs. In most situations, landscape managers have little real control over their landscapes. Inherited landscapes are often full of overgrown plants or plants that have been pruned incorrectly for a long time. You can't change the plants and it would take more time than you have to correct past pruning mistakes. In short, you don't have control over the landscape. Labor costs can have a tremendous impact on pruning practices. Shearing is fast and easy which means you can cover a lot of ground in a hurry. In contract work, I feel it is inevitable that most landscapes will end up being sheared just because of the cost factor.

Finally, a big problem is a lack of expertise on the part of people doing the pruning. Pruners need a pretty broad knowledge of plants to do a good job. Five minutes of instruction aren't enough to become a good pruner. Too often, the people doing the pruning aren't the ones buying all of those books.

SOLUTIONS

Maybe we are going about this the wrong way. Perhaps instead of taking the plants perspective, we should take a people perspective. We need a system where we can prune more or less at our convenience, where we don't have to know a lot about plants, and where pruning techniques can be simplified. The pruning techniques I have in mind are shearing and rejuvenation. Shearing was discussed under the section on formal pruning. Rejuvenation involves cutting a plant back to within a few inches of the ground in the spring. With plants that respond to this approach, the result is vigorous growth and a natural looking plant.

The first step is for designers to sit down and ask how and to what extent a site will be maintained. If it is going to be maintained on contract and on a small budget, then everything should be simplified. As much as possible, use mass plants of evergreens well adapted to shearing, preferably those that will look good with one thorough shearing per year. Plant accent plants in large groups and pick only those that tolerate rejuvenation pruning. The idea here is that in a planting of nine Forsythias each year, three would be rejuvenated. Pruning is simplified and fast. You shear the hedge type plants and rejuvenate a portion of the natural type plantings.

Because of the group plantings, the selective rejuvenations are hardly noticed. In the case of the Forsythias, the planting always looks natural, always flowers, and never gets overgrown. The site looks tidy and well cared for but doesn't take a lot of time or expertise to maintain. It certainly looks better than the typical shopping center where forty different plants were used and all end up sheared into one big hedge.

I imagine there are other plausible schemes for developing attractive landscapes that can be economically maintained. The important point is to plan for the inevitable and make the most of it. It doesn't do any good to lament the "destruction" of a landscape that could only shine in the hands of a skilled professional.

CONCLUSIONS

Pruning in the "classic style" is still the right goal. When feasible, all plants should be pruned according to their needs. It is important, however, to recognize most commercial and institutional landscapes don't lend themselves to plant oriented pruning. For the sake of speed, economy, and convenience, other approaches are necessary. Careful choice of plant materials to accommodate simplified pruning styles can leave a "cultured" look instead of the "butchered" look we see so often today. Our pruning goals should be to get the best appearance possible given the resources we have available. This may require use of sharing the rejuvenation techniques in many cases.

NOTE

If you haven't found a good pruning book, I suggest you try the one listed below. In this book Mr. Brown has produced one of the most detailed and extensive pruning encyclopedias I have ever found. Information in the first five chapters ranges from good to ridiculous and much of his advice on wound treatments is outdated, but he more than makes up for it in chapter six where he details needs of specific plants.
The Pruning of Trees and Conifers
by George E. Brown 1972
ISBN 0571-11084-3

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