TURFGRASS
NUTRIENT AND INTEGRATED PEST MANAGEMENT MANUAL

EDITOR:
TIMOTHY M. ABBEY

Supported By:
Connecticut Department of Environmental Protection
Connecticut Grounds Keepers Association
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College of Agriculture and Natural Resources, University of Connecticut
Convert problem turfgrass areas into ornamental plant beds.

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Note: This publication was accurate at the time of its original printing (2001). This 2009 reprint has made only minor corrections. An updated reference contact list may be found on page 112. All other content and individual references has been kept but may not be completely current as of the reprint date.


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Chapter 1: Introduction to Turfgrass Integrated Pest Management

Timothy M. Abbey and Dana Karpovich

Turfgrass is everywhere. Our yards, athletic fields and a wide assortment of unmanaged areas are covered by grass. The importance of this valuable resource is often overlooked. Grass plants, like any other plant or animal, are an intricate part of the surrounding environment. A lawn is a home to insects, worms and other creatures that serve as food for birds and other animals. Grass roots serve to anchor soil and prevent erosion. The grass plant can filter contaminants from rainwater and absorb many types of airborne pollutants such as dust, pollen and sulfur dioxide. Turfgrass plays an important role in converting carbon dioxide to oxygen, in moderating temperature (approximately 9°F cooler than asphalt and 10°F to 14°F cooler than bare soil) and in reducing noise levels by 20% to 30%. Turf also serves as a fire retardant and as a filter for runoff of soil and pesticides.

Along with the environmental benefits, turfgrass serves as a place of recreation for both adults and children and contributes to the overall aesthetic quality of any landscaped area. A well-maintained lawn adds to the beauty of a neighborhood (photo 1-1). An attractive lawn provides curbside appeal, drawing prospective buyers into a home, and has the potential to increase property value by 15%.

There are approximately 25 million acres of lawn in the United States. In 1999, consumers spent $7.9 billion on professional lawn and landscape services and an additional $9 billion on “do-it-yourself” lawn care products (Butterfield, personal communication). Therefore, there is a need for turf care professionals and homeowners to have access to useful turfgrass care and pest management information. The purpose of this manual is to provide both the professional and the homeowner with useful nutrient and integrated pest management (IPM) strategies and techniques.

WHAT IS INTEGRATED PEST MANAGEMENT?

Integrated pest management for turfgrass is a decision-making approach that uses a variety of methods to manage diseases, insects, weeds and other problems. The use of IPM for the maintenance of lawns can minimize risks to human health, society and the environment. Some IPM strategies include action thresholds, scouting or monitoring, correct identification of pests and pest damage, use of resistant turfgrass cultivars, proper cultural practices, biological and chemical controls, record keeping, equipment calibration and program evaluation.

Action Thresholds

IPM is not the complete elimination of pests, but rather the acceptance or tolerance of a number of pests or pest damage below an action, or tolerance, threshold. The action threshold is the actual number of pests, on average, per unit of measure. The action threshold is a somewhat difficult concept to grasp when dealing with lawn pests. For example, when considering white grub populations, it would be the number of grubs per square foot. However, this number can be affected by many factors such as turfgrass species, environmental conditions (e.g., soil moisture, temperature), potential for the pest to cause turf damage and tolerance level of the client for pests. Thus, action thresholds are usually presented in a range and not an exact number. Experience and a complete understanding of the situation can influence how a threshold impacts the decision-making process.

Cultural Practices

Successful maintenance of turfgrass depends on 2 factors: proper cultural practices and effective pest management. Cultural practices are activities such as mowing, watering, soil management, thatch management and fertilization. Improper cultural practices, specifically fertilization, can have a significant negative impact on the environment. Over-fertilization with water-soluble nitrogen, particularly fertilizer granules applied to impervious surfaces (drive- ways, roads, sidewalks), moves nutrients via rainwater runoff into storm drains and eventually into large bodies of water, such as the Connecticut River and Long Island Sound. The process of pesticide/fertilizer movement from numerous locations, such as home lawns, into water is called non-point source pollution.

Turfgrass vigor and appearance are negatively impacted by a wide assortment of organisms and human activities. Diseases, insects, weeds and improper cultural practices, alone or in combination, may cause turf to decline. Cultural practices are the basis for good turfgrass management and essential for the implementation of IPM. Proper fertiliza-
tion, irrigation and mowing practices can reduce the detrimental effects of these pests by improving turf vigor.

Examples of ways IPM and cultural practices can protect water quality and conserve water use:

**Mowing**
- Frequency and height of cut can increase plant density, decrease surface runoff and dictate water use depending on height of cut.
- Clipping management can be used to modify and manage fertilizer applications.

**Fertilizer**
- Use a soil test to determine nutrient needs.
- Time fertilizer applications to maximize plant growth and reduce movement of fertilizer off target areas.
- Fertilizer application rates and timing will be based on the source of nitrogen.

**Resistant Cultivars**
- New and improved cultivars (along with implementation of cultural practices) can aid in reducing irrigation needs, fertilizer and pesticide applications.
- Improved cultivars with proper management can influence plant density and vigor.

**Pesticides**
Pesticide use is a component of IPM. Pesticides are used when alternative methods fail to control pests, or when alternative strategies are not practical or cost effective. IPM is not organic lawn care. However, organic-based pesticides and fertilizers can be included in an IPM program. The first consideration for any pesticide use should be the selection of the least toxic material to successfully control the pest present. In certain cases, IPM can not always limit pesticide selection to the least toxic material. However, with IPM, the precise timing, correct application rate and proper use of a pesticide can lead to reductions in pesticide use. The overall goal is to use correct diagnosis and IPM strategies to reduce unnecessary or repeat pesticide applications, or, ultimately, to eliminate them completely.

**IPM FOR THE PROFESSIONAL**
Numerous detailed steps are necessary in order to take the IPM definition and make it a functional pest management plan. The 5 major IPM program components are:

1. **Know the turfgrass environment** – the growing conditions, the key pests, key damage locations and natural enemies (such as important parasites and predators).

2. **Inspect the turf area on a regular basis** both visually and, if appropriate, with traps. Use the information to set tolerance levels, or thresholds, and predict pest activity.

3. **Think of all the pest management options available and their respective pros and cons before making a decision.**

4. **Evaluate the outcome of each treatment decision and review the entire IPM program annually.**

5. **Keep detailed records of all monitoring activities and pest treatments, including chemical pesticide use, for each property. Thorough records establish a history that can be extremely useful with diagnosis of future problems.** They also provide accurate information if there is ever miscommunication between the client and the turfgrass professional.

**Know the Enemy**
Knowledge of agronomy, weed science, plant pathology and entomology would be the ideal background for anyone involved with turfgrass IPM. However, that is probably not going to be the case. It is more realistic to think that a lawn care professional has expertise in one field, and that the general public has limited knowledge of any of these disciplines. Knowledge gaps can be filled with development of a good reference library and by knowing where to go for professional diagnostic assistance.

For the professionals, remember that it is in your best interest to hire personnel that have a solid knowledge base and a willingness to learn. It is difficult enough to train people on the daily aspects of a job (billing, equipment operation, etc.) let alone add the scientific information dealing with the turfgrass environment.

If the turf pests and beneficial insects can not be identified correctly, then there is greater risk that the remaining IPM components will not work together as a successful program.

**Scouting, Scouting and More Scouting**
Scouting, or monitoring, is extremely important because all other components of IPM are linked to it. Scouting, or monitoring, is the visual inspection of plant material for pest activity on a regular basis (photo 1-2). The use of a hand lens can facilitate proper identification of specimens (photo 1-3). When applicable, traps for specific insect pests can assist with this process. Scouting helps to detect pests while population levels are low. This favors spot treatment rather than broadcast pesticide applications. There are a number of specifics that should be documented while scouting: topography of the landscape; turfgrass species; landscape plant species; weed species present and population levels; presence of disease; insect pest and beneficial species present and their numbers.

A potential hurdle when implementing an IPM program is how to monitor all the accounts on a regular basis (every one to 2 weeks) for pest problems. One way to address this problem is to focus on key pests in key locations. Detailed knowledge of each property (including the turf species present, past problems, etc.) can make scouting more efficient. For example, a property with a history of chinch bug infestations should receive more attention throughout the summer months. Whereas, one that has routine outbreaks of white grubs should receive more attention from mid-
scouting and experience are 2 factors that go into establishment of pest thresholds or tolerance levels. These come into play with decision-making. (A detailed list of scouting supplies and strategies can be found in Appendix A on page 107.)

Decision-making or How to Condense Extensive Detailed Information into a Simple, Effective Plan

Once all the components of the turf environment have been identified and viewed together as an interacting unit, a decision(s) must be made on how to improve the situation or manage the pest problem. The first step towards a successful turfgrass IPM program is utilization of proper cultural practices. If the turf species is maintained at its optimum growing requirements, the impact of pest species tends to be minimal. Thus, the decision-making process is simplified in that corrective measures are usually not warranted on healthy turf. However, combinations of pests, stressful environmental conditions and poor turf health conspire to make decision-making difficult. Turfgrass that is under serious attack from a disease or insects may force the final decision to be the application of a chemical pesticide.

Evaluation

It is important to follow up each treatment decision in order to evaluate its effectiveness. If the control did not work, then further investigation is necessary. If it was a chemical application, was the correct rate used? Was the product watered into the soil after application? For a biological release, was the percentage of live biological control organisms high enough to manage the pest population? If beneficial nematodes were used, were they watered into the soil after application? Was the pest population past the point of control?

Not only should individual management strategies be evaluated, but also the IPM program itself should receive an annual review. This can be done during the fall or winter when turfgrass, and most of the pests, are not active. At this time, you can see what pests were not brought under control. Was the optimum control window missed? If so, you can plan on earlier monitoring during the next growing season. Did the clients fully understand the services provided under the IPM program? If there were a number who complained, then new methods of communication should be developed. An annual evaluation can also help focus decision-making related to a specific pest. If an insect or weed was particularly troublesome, now is the time to research and locate sources of new biological, chemical and cultural control options.

Recordkeeping

Most people dislike extra paperwork. However, all of the pest management decisions and corresponding actions should be recorded in some fashion. IPM is information-intensive and to keep track of all the details in one’s head,
particularly with multiple accounts, is a challenging, if not impossible, task. The use of an organized scouting form can make the process easier. This form can be used to record the history of pest activity, turf conditions, treatments and treatment evaluations at each location. Separate pesticide application records should also be used to document what product(s) and how much were applied. These forms are necessary to conduct the annual IPM program review. All scouting information and pesticide use records can be stored on a computer instead of paper copies. Also, with a history of each property, new employees have access to valuable information that would have otherwise been lost. This reduces the chance that a known pest problem is overlooked.

**Communication Between Professional and Client**

For the turfgrass professional, it can be difficult to develop and sell an IPM program to clients. The first step when selling an IPM program is to make an initial site assessment and clearly establish reasonable pest management goals with the client. Homeowners must understand what an IPM program entails. Turf monitoring and sound decision-making are the primary services being provided, not regular pesticide or fertilizer applications. Pesticide applications and cultural practices are conducted with the long-term turf health in mind. Both the property owner and the lawn care professional must communicate clearly what is expected in the relationship.

**IPM FOR THE HOMEOWNER**

Homeowners must understand their role in the care of their lawn. The proper cultural practices discussed in the later chapters should be followed so that the turfgrass is vigorous. This is of vital importance whether the homeowner maintains the lawn or if a company is hired to provide these services. If a lawn care company is hired to maintain the lawn, understand the services that they provide. Remember that with a true IPM program you are paying for professional expertise and regular monitoring. When necessary, appropriate and timely pesticide applications are made. If this is not understood, problems may arise when the company makes a visit and no fertilizer or pesticides are applied. However, homeowners must understand that a treatment decision was made through a careful inspection and thought process. (For more information on how to hire the lawn care company to fit your needs, see Appendix B on page 107.)

**PROTECTING GROUND AND SURFACE WATER QUALITY**

IPM can influence water quality and water use on turfgrass. Proper pest management, along with the use of correct cultural practices, contribute to a vigorous and dense turfgrass stand (photo 1-4). A dense turfgrass stand is effective in reducing surface runoff and erosion, resists invasion from pests such as weeds, holds and reduces the likelihood of leaching from soluble nutrients such as nitrogen. In addi-

**REFERENCES**


Chapter 2: Soils

Edmond L. Marrotte and Karl Guillard

Soil is the medium in which turfgrass grows. The ideal soil for most turf grown around the home is fertile, deep, with as few rocks as possible, well drained and easily crumbled. Good growth is partially dependent upon a fertile soil. However, a soil with high nutrient levels may be quite unproductive because of poor drainage, insect or disease problems, weeds, lack of water, insufficient sunlight or other cultural factors. Infertile soils with good physical properties can be made productive by adjusting the pH and adding organic matter and fertilizer.

**SOIL CHARACTERISTICS THAT AFFECT FERTILIZATION**

Soils physically support plants and act as reservoirs for the water and nutrients needed by plants. Soils are complex mixtures of mineral particles of various shapes and sizes; living and dead organic materials including microorganisms; roots; plant and animal residues; and air and water. Closely interrelated physical, chemical and biological reactions occur constantly. The physical condition of the soil greatly influences the nature of biological and chemical reactions. Optimum plant growth depends as much on a favorable physical environment as it does on the fertility of the soil.

The primary physical characteristics of a soil are its particle size distribution (texture) and the arrangement of the individual soil particles into larger units (structure). Texture and structure determine the pore space between particles. Pore space is necessary for the movement of water, dissolved nutrients and air, and for providing space for roots to grow. The organic matter content of a soil also affects its physical characteristics.

**Soil Texture**

Soil texture is a term that describes the mixture of different sizes of mineral particles. It relates primarily to particles smaller than 2 millimeters (0.08 in) in diameter — sand, silt and clay; these are the particles most active in the soil processes that support plant growth. Coarser particles, such as gravel and stones, are either chemically inert or interfere with plant cultivation (figure 2-1).

Sand, the coarsest of the particles, feels gritty when rubbed. Sandy soils usually have rapid water infiltration and good aeration, but low water holding and nutrient storage capacity. However, there is a considerable range in these properties within the sand fraction.

Silt, the intermediate size, feels smooth when dry and slippery (but not sticky) when moist. Because the smaller particle size creates smaller pore spaces between particles, silty soils have a slower water intake rate but higher water-holding capacity than sandy soils. Silt is an essential component of the medium textured, versatile soil called loam.

Clay, the finest of the soil particles, gives the soil a sticky or plastic feel and cohesiveness. One property of clay is an attraction (called adsorption) for positive ions (cations) such as calcium, magnesium, potassium and ammonium. This property allows the clay component in soils to store large quantities of the plant nutrients that form positive ions. This storage capability is referred to as cation exchange capacity (CEC) and is discussed later. On the other hand, plant
nutrients that form negative ions (anions) may be adsorbed very strongly (e.g., phosphate) by clay, while others (e.g., nitrate and chloride) are not adsorbed at all and are subject to leaching. Clay, partly because of its small particle size and partly because of the positive ions associated with it, also has a strong attraction for water.

The soil texture directly influences the amount of nutrients a soil can hold. More nutrients and water are held with a finer soil texture. To supply the same amount of nutrients to plants, a sandy soil requires more frequent applications at lower rates than a finer textured soil.

Various combinations of sand, silt and clay make up the soil. There is no accepted definition for the term “topsoil.” Therefore, any soil, no matter what its texture, can be topsoil as long as it is on top. If you are ordering topsoil, make sure the material is what you want.

**Soil Structure**

Soil structure refers to the arrangement of soil particles into larger, secondary units. Sand, silt and clay particles seldom occur as separate units in the soil, rather, they combine into aggregates held together by the small binding forces of clay and organic matter. The size and form of the aggregation determine the structure of the soil. Soil structure is one of the more important physical characteristics of soil. Plant growth is strongly influenced by soil structure because of its effects on the movement of water, air and roots (figure 2-2).

A granular soil structure provides an ideal environment for plant roots and is particularly suitable for establishing plants from seeds or transplants. Pores between the granular aggregates are large and continuous, and roots penetrate them easily.

Water drains readily through a granular soil, yet sufficient moisture is held in the aggregates to supply root needs. One of the good features of clay is that it promotes the formation of granular structure in medium textured soils by swelling and shrinking as it alternately absorbs water and dries out.

Although some breakdown of soil structure within the upper foot of soil may be inevitable in land that is intensively cultivated, an understanding of soil texture and structure promotes the use of cultural practices that minimize structural breakdown. Structural breakdown is easier to prevent than to cure.

**PRACTICES THAT HELP PREVENT STRUCTURAL BREAKDOWN**

1. Till soil with intermediate moisture content—not too wet, not too dry. Judging soil moisture content requires experience, but there is a general test. The soil is dry enough to till if a soil ball that is squeezed in the hand falls apart when tapped.

2. Avoid re-compaction of freshly till ed or loosened soil. The less activity in an area after tilling, the better.

3. Make paths on the smallest amount of land possible. For example, try to use the same paths for moving equipment during turf renovation.

4. Use heavy equipment on the lawn only when the soil is as dry as possible, within the limitations of weather.

If compaction is severe, it is possible to rejuvenate the structure. Some factors that favor the formation of granular structure are:

1. Wetting and drying, or freezing and thawing, of soils improves aggregation through swelling and shrinking.

2. Decomposition of organic matter produces gums that help bond soil particles together.

3. Mechanical aeration of the soil, when dry.

**SOIL ORGANIC MATTER**

Soil organic matter consists of animal and plant remains in various states of decomposition and the microorganisms (fungi and bacteria) that feed upon these remains. Fresh animal and plant matter begin to decompose as soon as they are added to the soil. At the same time, the microbial population increases rapidly. The microorganisms consume the animal and plant remains as their food supply and then die, thereby adding themselves to the organic material. The end product of decomposition is humus. Humus is dark brown to black and decomposes at a very slow rate. It is the component responsible for making some soil appear black and for the dark color in topsoil.
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Temperature and oxidation are the 2 main factors affecting the organic matter content of soil. Sandy tropical soils, for example, are typically low in organic matter, whereas poorly drained wetlands accumulate it. Because temperature and soil type are rather permanent factors, it is not easy to alter a soil’s organic matter level except through massive additions of plant residues or a drastic alteration in land use. Tilling, for example, stimulates organic matter decomposition. For this reason, the level of organic matter in a tilled soil usually is lower than it was before the soil was put into cultivation, unless plant residue is tilled in.

**Importance**

As fresh organic matter decomposes, the nutrients it contains are converted to inorganic forms for use by plants. The soil microorganisms use a portion of the nutrients, but when they die and decompose, the nutrients are again released. Organic matter, therefore, can be an important source of nutrients. In addition, organic acids released during decomposition of organic matter help to release nutrients from the mineral portion of the soil.

As organic matter decomposes, it becomes altered chemically, acquiring a negative electrical charge that attracts and holds inorganic elements with a positive charge such as potassium, calcium, magnesium and several of the micronutrients such as copper and iron. The elements held in this way are readily available to growing plants. Rain cannot easily wash away elements “held” by organic matter.

Organic matter helps to improve the structure of soils. Microorganisms secrete sticky glue-like materials that help bind individual microscopic clay particles into larger, more stable clumps, called aggregates. These aggregates do not break down easily when water is added or when the soil is tilled, and they resist compaction. Pore size is small within aggregates, enabling them to retain moisture. Spaces between aggregates are larger, thus improving infiltration, drainage and aeration. Such a soil is said to have good structure. Root development is better in a well-structured soil. Preferred aggregate size is between that of a BB (1/8 inch) and a large pea (1/4 inch).

Organic matter increases the moisture-holding capacity of soil because organic particles absorb water like a sponge. Plants use some of this water – an important consideration for sandy soils.

**Limitations**

Even though organic matter is very valuable for soil improvement, it does have shortcomings, and there are some popular misconceptions concerning its value. Organic material generally supplies some nutrients to plants, but it does not always supply 100% of the plant’s needs. For example, any plant remains that have been exposed to rain before being added to the soil are likely to be low in potassium because potassium leaches readily from plant material.

Materials such as sawdust, straw or wood chips are very low in nitrogen. In order for soil microorganisms to decompose such materials mixed into the soil, they must obtain additional inorganic nitrogen from the soil thereby competing with growing plants. As a result, nitrogen is in short supply for plants to use unless additional nitrogen is added in the form of fertilizer. On the other hand, a material high in nitrogen, such as alfalfa hay, could provide too much nitrogen and consequently promote excessive vegetative growth if too much is applied. Excessive turf growth can make the lawn more susceptible to certain disease and insect pests.

A point to remember: a growing plant cannot use nitrogen, phosphorus and sulfur from organic materials unless they are converted to an inorganic form through the process of “mineralization.” The elements supplied by a store-bought fertilizer are also in inorganic form. A plant cannot distinguish between a nitrogen atom that originally came from organic amendments such as manure and one added as a commercial or chemical fertilizer.

**REFERENCES**


Temperature and oxidation are the 2 main factors affecting the organic matter content of soil. Sandy tropical soils, for example, are typically low in organic matter, whereas poorly drained wetlands accumulate it. Because temperature and soil type are rather permanent factors, it is not easy to alter a soil’s organic matter level except through massive additions of plant residues or a drastic alteration in land use. Tilling, for example, stimulates organic matter decomposition. For this reason, the level of organic matter in a tilled soil usually is lower than it was before the soil was put into cultivation, unless plant residue is tilled in.

**Importance**

As fresh organic matter decomposes, the nutrients it contains are converted to inorganic forms for use by plants. The soil microorganisms use a portion of the nutrients, but when they die and decompose, the nutrients are again released. Organic matter, therefore, can be an important source of nutrients. In addition, organic acids released during decomposition of organic matter help to release nutrients from the mineral portion of the soil.

As organic matter decomposes, it becomes altered chemically, acquiring a negative electrical charge that attracts and holds inorganic elements with a positive charge such as potassium, calcium, magnesium and several of the micronutrients such as copper and iron. The elements held in this way are readily available to growing plants. Rain cannot easily wash away elements “held” by organic matter.

Organic matter helps to improve the structure of soils. Microorganisms secrete sticky glue-like materials that help bind individual microscopic clay particles into larger, more stable clumps, called aggregates. These aggregates do not break down easily when water is added or when the soil is tilled, and they resist compaction. Pore size is small within aggregates, enabling them to retain moisture. Spaces between aggregates are larger, thus improving infiltration, drainage and aeration. Such a soil is said to have good structure. Root development is better in a well-structured soil. Preferred aggregate size is between that of a BB (1/8 inch) and a large pea (1/4 inch).

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**REFERENCES**


Soils Online: www.hintze-online.com/sos/soils-online.html#41
Chapter 3: Fertilizers and Plant Nutrition

Karl Guillard

Turfgrass Fertilization

Turfgrass growth and quality are strongly influenced by the availability of nutrients in the turf-soil ecosystem. In many instances, there may be little or no need to fertilize turf. In other cases, fertilization is needed to maintain turfgrass stand persistence and quality. Nutrient needs of turf and whether or not to fertilize are determined by many factors; these will be discussed in this chapter. When fertilization is required, however, water quality concerns from fertilizer nitrogen and phosphorous runoff and leaching need to be considered. Proper fertilization does not mean over-fertilization. Appropriate fertilization practices provide the necessary nutrient levels required for healthy turf, while minimizing the threat to receiving waters from nutrient pollution by runoff or leaching.

Proper fertilization of turfgrass is extremely important because of the high demands for turf quality, the wide use and establishment of turfgrasses under less than favorable conditions, and the great demands placed on turf for high recuperative capacity and wear tolerance. This requires a high level of cultural expertise including knowledge of plant nutrition, soils and fertilizer technology and application. Some of the variables to consider when preparing to apply fertilizer are: turfgrass species, mowing height and frequency, soil type and structure, whether irrigation is applied, the intended use of the turfgrass, environmental factors such as shade or sun, temperature, and whether clippings are returned.

There are at least 16 elements that are considered essential for turfgrass growth. Those required in relatively large amounts are called macronutrients – carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S). Those required in relatively smaller amounts are called micronutrients – iron (Fe), manganese (Mn), zinc (Zn), boron (B), molybdenum (Mo), copper (Cu) and chlorine (Cl). Turfgrasses obtain C, H and O from the atmosphere and water; the remaining elements are obtained by the roots from the soil.

Macronutrients may be present in large quantities in most soils, but their availability in the soil may be low. When below sufficient availability, N, P and K are most often supplied by applying turf fertilizers. Calcium and Mg are routinely supplied from liming materials. Sulfur fertilization of turfgrasses is not usually needed in Connecticut because S requirements are met through atmospheric deposition of S-containing air pollutants and S mineralized from organic matter. Sulfur is also a component of some N- and P-containing fertilizers and certain pesticides.

Micronutrients are rarely deficient in Connecticut soils, and it is normally not necessary to apply them on a routine basis. The only exception to this may be with Fe. This is not, however, based on a deficiency of Fe in the soil, but that application of Fe, particularly as a foliar spray, has been shown to increase the dark green color in cool-season turfgrasses resulting in higher turf color quality. In many cases, it may be possible to reduce N fertilization when Fe is applied, without a loss in turf quality.

Fertilization of turfgrasses should be based on nutrient inputs and outputs in any particular site or turf system. Nutrient inputs include fertilization, atmospheric deposition, organic matter decomposition and residue additions (i.e., return of clippings). Outputs of nutrients from a turf system include the removal of clippings, gaseous losses (denitrification and volatilization), losses through percolating water (leaching) and immobilization in the soil organic matter or mineral fractions. When the supplying capacity is sufficient, then there is little or no need for fertilization. In fact, fertilization in these cases when available nutrients are adequate leads to less healthy turf and increases the potential for water pollution.

The capacity of any particular turfgrass stand to secure available nutrients from the soil influences the fertilization requirements. Factors to consider that may influence the ability of a turfgrass to obtain essential elements:

- **Root extent and depth**: roots can only absorb nutrients where they are growing. Therefore, conditions that favor deep and extensive root development improve nutrient uptake capabilities. Compact and/or wet soils have restricted rooting depths and this may prevent adequate nutrient uptake. Over-fertilization of turf, especially with soluble N forms, stimulates excessive shoot growth at the expense of root growth.

- **Thatch layer**: if there are many roots in the thatch layer, nutrients in the soil root zone will not be obtained and soil tests may incorrectly describe the nutrients available to the roots. In contrast, a thick thatch layer can bind up fertilizer so that it does not reach the roots in the soil. (Thatch is discussed in detail in chapter 8 on page 83.)

- **Organic matter decomposition**: the amount and rates of mineralization affect the nutrient availability and existing fertility of a soil. Soils with high organic matter content may not need as frequent fertilizer applications as soils with low organic matter content.

- **Soil pH**: the solubility of all essential elements and soil microbial activity is affected by pH. It is generally recommended to maintain a soil pH between 6 and 7 for turf-
grasses, although they can grow reasonably well over a wide range of pH values.

- **Cation Exchange Capacity**: finer textured soils have a higher CEC and a higher nutrient supplying capacity than coarse textured soils. Therefore, less frequent fertilizer applications may be required on fine textured soils than on coarse textured soils.

- **Losses**: gaseous and nutrient losses via leaching and runoff decrease the amount of nutrients available for turf growth. Avoid overwatering of turf and apply fertilizers at the appropriate times and rates to minimize the loss of soluble nutrients.

### Determining the Need for Specific Nutrients

The use of a soil test should form the foundation of a turfgrass fertilization program. Soil tests are routinely used to determine the availability of P, K, Ca and Mg. Micro-nutrients may also be determined by a soil test, but are usually an additional cost. Normally, turfgrasses do not have a great need for micronutrients. However, occasional testing may be useful particularly if a turf problem persists and no answer can be found. Soil tests for N are available, but their value for turf is negligible because the rapid transformations that can occur for the various forms of N in the turf-soil system make the tests largely meaningless.

Consequently, N fertilization needs for turf have been based historically on various measures of turfgrass species growth and quality such as clipping yield, color, visual symptoms of N deficiency, shoot density, tillering, rooting characteristics, recuperative capacity, etc. Past fertilization practices and responses are useful guides for N fertilization. Tissue tests are becoming more widely utilized, but are expensive compared to a soil test. Color meters or light reflectance meters may prove to be useful in a turfgrass N management program.

Other conditions and factors affect the need for specific nutrients. The inherent nutrient supplying capacity of the soil and organic matter mineralization potentials may decrease or increase the need for specific nutrients based on turfgrass performance and quality goals. Incidence and severity of diseases, insects and other pest problems may demand changes in current fertilization practices, as may abiotic environmental stresses such as drought, heat or cold conditions. Increased traffic directly and indirectly affects nutrient needs and uptake. To a great extent, clipping management (returned vs. removed) affects the availability and nutrient status of a turfgrass soil. When clippings are returned to the turf, fertilization rates may be decreased by as much as 50% without loss in quality. Contrary to popular belief, grass clippings do not contribute to thatch and should be returned whenever possible for healthy turf.

Common sense should provide a guiding influence on nutrient management programs for turf. There are certain situations when turfgrass fertilizer applications need to be closely managed due to potential negative environmental effects. For example, fertilization (especially excess nutrient application) near open water bodies or on sites with high leaching potentials may contribute to contamination of groundwater and receiving waters. In these cases, the source of N, timing of application and rate applied need to be carefully considered. (For additional information on fertilizer grades and ratios, see Appendix C on page 108.)

### Importance of Specific Nutrients to Turfgrass Growth and Development

Although all essential elements are involved and needed for adequate turfgrass growth and development at some concentration in the grass tissues, there are certain elements that are more frequently associated with specific growth responses in turf. The table at left indicates the turfgrass growth responses that are primarily affected by specific nutrients.

#### NITROGEN

Nitrogen is typically the nutrient required in the greatest quantity by turfgrasses. Turfgrasses usually contain 2% to 6% N on a dry weight basis. When turf soils do not provide an adequate amount of N, persistence and quality of the turf suffers. This is usually expressed by reduced turf growth and development, reduced shoot and tiller density, increased weed infestations, and a yellowing of the leaf blades, which reduces visual quality (photo 3-1). It is critical that correct amounts are supplied at appropriate times in appropriate amounts. It is easy to see when turf is lacking N, but much harder to determine when N availability is past adequate and excessive. It is commonly known that N fertilization results in a darker green leaf color, but consistent excessive N fertilization for a dark green turf color may not be beneficial in the long run. Although a dark green

<table>
<thead>
<tr>
<th>Turfgrass Growth Response</th>
<th>N</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooting</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Shoot Growth</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(leaves, tillers, rhizomes, stolons)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Establishment</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(germination and seedlings)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Stress</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Resistance and Tolerance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>drought</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>heat</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>cold</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Disease Susceptibility</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wear Tolerance</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(ability to tolerate heavy use)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recuperative Potential</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(ability to recover from damage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composition of Turf Community</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(turfgrass species present)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
turf color is usually most desirable in our culture, this should not be always equated with the highest turf quality.

Under consistent and high N rates, turfgrass health is compromised. Excessive N availability can result in poor root growth because shoot growth is stimulated at the expense of the roots; poor rhizome and/or stolon development resulting in a weak sod; higher incidence with hot-weather diseases; reduced storage of food carbohydrates which are needed for regrowth, stress periods and overwintering; reduced recuperative ability; poor tolerance to heat, cold, traffic and drought stresses; shifts of the turf community to species that are favored by high N (e.g., annual bluegrass); higher succulence resulting in less wear tolerance; more frequent mowing; a higher burn potential with certain types of N fertilizers; and environmental and economic losses of N.

**Nitrogen Sources**

Nitrogen can be found in various fertilizer formulations, either as a readily available form (highly soluble in the soil solution – fast-release) or in a slowly available form (low solubility in the soil solution – slow-release). The fast-release forms are composed of inorganic salts such as calcium nitrate (15.5% N) and potassium nitrate (13% N), or are synthesized by reacting ammonia with various compounds to form urea (45% to 46% N), ammonium nitrate (33% to 34% N), ammonium sulfate (21% N), or mono- and diammonium phosphates (11% to 20 % N).

**The advantages of the fast-release forms:**
- Have a high percentage of N by weight.
- Provide an immediate response.
- Have minimal temperature dependency that provides good response under cold temperatures in spring and fall.
- Are relatively inexpensive per unit of N.

**The disadvantages of the fast-release forms:**
- Provide only a short-term response and their effectiveness lasts only 4 weeks or less which necessitates more frequent applications.
- Have a high salt index and a high foliar burn potential and need to be watered in immediately after application (photos 3-2 and 3-3).
- Have a higher leaching potential because of their solubility.
- Have a higher volatilization potential especially with the ammonium-containing forms.
- Have a higher denitrification potential especially with the nitrate-containing forms.
- Impart an acidifying effect in the soil solution.

Because of the fast-release properties, turf response from soluble N sources is often characterized by short bursts of growth after application followed by periods of slow growth as the N is rapidly depleted or lost from the soil. The process is repeated over again with each subsequent N application. The peaks and valleys in growth not only result in a greater mowing frequency shortly after application, but also can quickly deplete food carbohydrates in the grass. This has a highly negative effect on root growth and gradually may cause the turf to thin out.

The slow-release forms of turfgrass N fertilizers are derived either by reacting urea with various organic or inorganic compounds to form ureaformaldehyde (38% N), isobutyli-
dene diurea (IBDU, 31% N) and sulfur coated urea (22% to 38% N), or are derived from natural organic materials or residues – manure, compost, bloodmeal, food industry by-products, biosolids, etc.

**The advantages of slow-release fertilizers:**
- Provide a more uniform turfgrass growth during the growing season, and do not produce the peak and valley growth as is often observed with fast-release forms.
- Have a lower salt index and a lower foliar burn potential in most situations.
- Have a long-term turfgrass response and can carry over from year to year.
- Have a lower potential for leaching, denitrification and volatilization loss.
- Need to be applied less frequently; and with the natural organic forms, they often supply other nutrients and can suppress certain turfgrass diseases.

**The disadvantages of the slow-release turfgrass fertilizers:**
- Higher cost per unit of N.
- May not supply sufficient N needed by the grass.
- Some are more dependent on temperature for release than the fast-release forms.

Because of advantages and disadvantages of fast- and slow-release forms, some turfgrass fertilizers are blends of both fast- and slow-release N carriers which combine the advantages and reduce the disadvantages associated with each type.

**Specific Characteristics of Slow-Release Nitrogen Fertilizers**

**Ureaformaldehyde**

Ureaformaldehyde (UF) is synthesized by combining urea with formaldehyde, which forms a compound containing units of methylene urea. Available N from UF is dependent upon microbial hydrolysis of the carrier and is temperature dependent. Solubility of this material is based on molecular weight (chain length) of the formulation. With UF, the shorter the length of subunits, the greater the solubility. The following terms are used in the discussion of specific fertilizers:

**CWSN**: cold water soluble N, the % of N that is immediately released

**CWIN**: cold water insoluble N, the % of N that is slowly released; sometimes referred to as HWSN (hot water soluble N)

**HWIN**: hot water insoluble N, the % of N that is slowly released

**AI**: activity index is the % of CWIN that is soluble in hot water (HWSN); the higher the AI, the more rapidly the N is solubilized.

The CWSN fraction of UF represents the low molecular weight short chains of unreacted urea plus methylene urea. The CWIN fraction of UF represents the larger chain lengths, which have higher molecular weights. The HWIN fraction of UF represents the very large chain lengths that have very high molecular weights. At 77°F, the CWSN of UF is readily absorbed by turfgrasses. Typically, there is little or no response to UF when applied during cold temperatures because microbial activity is minimal. A UF carrier should have an AI of at least 40% to supply sufficient N.

Another expression of UF-N solubilization characteristics is the urea:formaldehyde ratio. Since UF is synthesized by combining urea with formaldehyde (unreacted urea plus methylene ureas with varying chain lengths), some commercial formulations are manufactured with a urea:formaldehyde ratio of 1.3:1. This provides about 25% CWSN and 75% CWIN. A more soluble formulation can be obtained with a urea:formaldehyde ratio of 1.9:1, which provides 67% CWSN and 33% CWIN. The solubility of UF can be controlled by the ratio. It is desirable to have some N immediately available and the remaining made available in small amounts with time. Some commercial UF products are Nutralene, Coron, FLUUF, N-Sure, Nitro-30, NitroForm, Scott’s Contec and Lebanon’s Meth-Ex 40.

**Isobutyridene diurea (IBDU)**

IBDU is formed by combining urea with isobutyraldehyde. The solubility of IBDU is not influenced by microbial activity. Instead, the availability of N is dependent on chemical rather than microbial hydrolysis. With IBDU, N release is faster with smaller particle sizes (low mass:surface area), acidic soil pH, high moisture and warmer temperatures. Below a pH of 5, the rate of N release for IBDU is very rapid. The rate of N release from IBDU is up to 3 times faster at 75°F than at 50°F. Usually, there is a slower response in the spring with IBDU, but N response is faster if applied the previous fall. This allows more time for breakdown over the winter. It is common to blend different particle sizes of IBDU so that N is released over a 3- to 4-month period. A product with particle sizes ranging between 8 and 24 mesh is best for turfgrasses. Most commercial IBDU products are listed as IBDU but it can also be found in Lebanon’s IsoTek31.

**Sulfur-Coated Urea (SCU)**

SCU is formed when urea granules are coated with sulfur and a thin coating of sealant or polymer (wax, resin). Water diffuses in and out of micropores in the coatings until sufficient pressure builds up to cause breakage of the coating. The same factors that affect the N release of UF, also affect SCU (high moisture, higher temperatures). The initial turfgrass response to SCU is fairly rapid and is faster than UF and IBDU. With SCU, there is nonuniformity in the coating thickness, which provides varying release rates. It is common to blend thin, medium and thick-coated granules so that N is released over a 6- to 8-week period or longer.
The N in SCU is not defined as a water insoluble N (WIN, same as CWIN) and is often listed as a controlled release N (CRN) and characterized by a 7-day dissolution rate value. The 7-day dissolution rate value is the % of N released from SCU in water at 95°F in one week under laboratory conditions. Most commercial SCU formulations have a 7-day dissolution rate of 20% to 30%. This means that 20% to 30% of the N is quickly released and 80% to 70% of the N is slowly released. A dissolution rate below 20% indicates a material with N that is probably too slowly available for most turf purposes and a dissolution rate above 30% indicates a material that would not be considered a slow-release N source. Some commercial SCU or polymer coated urea products are Scotts POLY-S, LESCO Poly Plus, POLYON and TriKote.

**Fertilizers Derived from Organic Materials**

There are many different types of turfgrass fertilizers derived from natural organic sources. These materials are typically lower in N and usually more expensive per unit N than synthetically derived products, but offer these advantages for use on turfgrass:

- Natural organic fertilizers have low potential for foliar burn.
- Low leaching and volatilization potential.
- Slower acidifying effect on soil pH.
- Provide a wide range of essential elements.
- Help suppress certain turfgrass diseases.
- May improve the physical properties of the turf soil.

Release of N from organic fertilizers is dependent on microbial activity. Depending on conditions, N release from organic fertilizers can be relatively rapid or may be immobilized within the soil organic matter and not released for many months.

The most widely recognized natural organic fertilizer for turf is Milorganite – an activated sewage sludge (biosolid) from the Milwaukee Sewage Commission. This material is inoculated with microbes, aerated to promote flocculation of the organic matter, filtered, dried, ground and screened. It is widely applied to golf greens and has a N grade of 6%. The following is a listing of some natural organic materials that are commercially available for turf. More products are sure to be offered because of the need to utilize organic wastes and the desire of many to utilize natural organic turf care practices.

For a more comprehensive list of organic fertilizers and amendments, contact the Appropriate Technology Transfer for Rural Areas (ATTRA), P.O. Box 3657, Fayetteville, AR 72702, Phone: (800) 346-9140, FAX: (501) 442-9842. Ask for the Sources for Organic Fertilizers and Amendments, Agronomy Resource List. This can also be obtained from their website: http://www.attra.org/attra-pub/orgfert.html

**Fertilizer Programs**

Frequency and intensity of fertilization depends upon the many factors discussed here.

**Species**

Less fertility is required for the fine leaf fescues, redtop, Canada bluegrass, common types of Kentucky bluegrass, and turf type tall fescue. Higher fertility is required for improved types of Kentucky bluegrass, perennial ryegrass and bentgrasses.

**Environmental Conditions**

Shaded turf requires less N than turf growing under full sun conditions. Reduce N rates by 1/3 to 1/2 in shaded areas.

Higher precipitation and irrigation rates increase the amount of N lost through leaching and denitrification, therefore more frequent fertilizer application, but at lower levels, may be required.

<table>
<thead>
<tr>
<th>Product</th>
<th>Derived from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milorganite</td>
<td>biosolid</td>
</tr>
<tr>
<td>Sustane</td>
<td>composted turkey waste</td>
</tr>
<tr>
<td>Ringer</td>
<td>blood/bone/feather meal</td>
</tr>
<tr>
<td>Toro BioTech</td>
<td>composted manure</td>
</tr>
<tr>
<td>Harmony</td>
<td>biosolids</td>
</tr>
<tr>
<td>Nutri-Wave</td>
<td>aquaculture byproducts</td>
</tr>
<tr>
<td>North Country Organics</td>
<td>various sources</td>
</tr>
<tr>
<td>U.S.AmeriGro SoilRich</td>
<td>biosolids</td>
</tr>
<tr>
<td>Scotts BioTech</td>
<td>composted manure</td>
</tr>
<tr>
<td>EarthWorks Replenish</td>
<td>poultry compost</td>
</tr>
<tr>
<td>Nature Safe</td>
<td>blood/bone/feather/</td>
</tr>
<tr>
<td></td>
<td>meat/fish meal</td>
</tr>
<tr>
<td>A-Maizing Lawn, Wow!, Safe 'N Simple</td>
<td>corn gluten meal</td>
</tr>
<tr>
<td>Renaissance</td>
<td>soybean protein</td>
</tr>
<tr>
<td>Vita Build</td>
<td>compost</td>
</tr>
<tr>
<td>Turf Cocktail</td>
<td>fish meal</td>
</tr>
<tr>
<td>Planet</td>
<td>green compost</td>
</tr>
<tr>
<td>Bay State Fertilizer</td>
<td>biosolids</td>
</tr>
<tr>
<td>Neptune's Harvest</td>
<td>fish hydrolysate</td>
</tr>
<tr>
<td>Natural Science</td>
<td>leather tankage</td>
</tr>
</tbody>
</table>

If high rates of N are applied to cool-season turfgrass during high temperatures, shoot growth is rapidly stimulated, reducing food carbohydrates and negatively affecting root growth. Disease susceptibility also increases. Turf decline follows.

**Soil Characteristics**

Most soils in Connecticut have a high P-fixation potential and are regulated by soil pH.

Sandy soils require more frequent fertilizer applications than soils with more clay and silt.

Soils with high organic matter content or more clay and silt require less fertilizer than sandy soils or soils with lower organic matter content.
Maturity of Turf Stand

There is a greater fertility need for turf at establishment and less so as the stand matures. More P is needed during early growth stages.

As turf matures and the stand reaches approximately 25 years in age, there is a greater potential for N losses because the storage potential of the soil organic matter is maximized. When soil organic matter is maximized, less N application is needed because mineralization of the soil organic matter releases N to the turf.

Length of Growing Season

The longer the growing season, the more nutrients required to sustain turf growth and quality.

Mowing Height

As mowing height is lowered, individual shoots become smaller and turf density increases. Therefore, smaller amounts of N fertilizer should be applied because higher rates may burn the leaves due to collection of fertilizer on the denser leaf surface.

Clipping Management

Returning clippings to the turf markedly reduces fertilizer needs. UConn studies indicate that N fertilizer rates can be reduced by 50% or more without a loss in turf growth and quality when clippings are returned. Contrary to popular belief, grass clippings do not contribute to thatch.

Turf Use and Objectives

Athletic fields and golf courses require more frequent applications of fertilizers to recover from traffic and injury than home lawns. Home lawns do not need the fertilization received by athletic fields, and therefore, should not follow fertilization practices intended for athletic fields.

Because of the different variables, turfgrass fertilization programs are site specific. Therefore, it is important for the turf manager to evaluate each site and its particular combination of features before initiating a fertilization program.

Fertilization Frequency

If needed, an ideal turfgrass fertilization program would consist of frequent applications of very small amounts of nutrients during the growing season to meet growth requirements without overapplication. With this program, the turf manager would be able to control nutrient needs quickly. This type of program, however, is not practical for most turf sites except for high value turf such as golf courses and high-end athletic fields that are given day-to-day attention by a turf manager assigned to the site. The term “spoon feeding” is used for these types of fertilization programs and nutrients such as N are applied at rates of approximately 0.1 to 0.25 lb N/1000 ft²/application or less, over many times during the season. This program of repeat applications of small amounts of fertilizer is not for use on home lawns.

Most turf sites in Connecticut require at least one and up to 3 or 4 N applications per season for acceptable growth and quality. Less frequent applications of P and K are needed. The more intensively a turf is managed, however, the more frequent the need for nutrient applications. Frequency of fertilizer applications can be minimized with slow-release and natural organic fertilizer sources. Because of lower CEC, sandy soils are fertilized more frequently than loam or clay soils. Ultimately, the presence and availability of essential plant nutrients determine the minimum fertilization frequency at which acceptable turfgrass growth and quality occur. For N, this is determined by turfgrass growth response and for other nutrients by using a soil or tissue test.

Nitrogen Fertilization Rate

The maximum amount of N that may be safely and sensibly applied at any one time depends on the form and carrier of N, temperature, time of year, mowing height, species and turf use.

- In Connecticut, 2 lb of N for each 1000 ft² of turf per year is usually sufficient for good growth if you leave the clippings on the turf. Up to 3 to 4 lb of N/1000 ft² per year often is applied, but the extra fertilizer usually does not increase the quality of the turf, unless the clippings are removed.

- Nitrogen fertilization rates greater than 2 lb/1000 ft² per year with clippings left on the turf increases the number of times a lawn must be mowed, and increases the potential for nitrate to escape the lawn and contaminate surface and/or ground water.

- Under favorable conditions in Connecticut, soluble N-containing fertilizers should be applied to provide no more than 1 lb N/1000 ft² at any one application. Apply soluble N-fertilizers only when turf is dry and when temperatures are below 80°F. After application, apply water to wash the fertilizer off the foliage. Rates higher than 1 lb N/1000 ft² may cause burn or excessive shoot growth.

- When the temperature is above 80°F, N application should be avoided or limited to no more than 0.5 lb N/1000 ft² at any one application.

- With the natural organic materials, slightly higher rates may be used, but no more than 3 lb N/1000 ft² should be applied at any one time. Reduce the number of applications by 1/2 when natural organic sources are applied at rates greater than 1 lb N/1000 ft².

Because the grade in different turf fertilizers varies, you need to determine how much fertilizer to apply to any given turf area. Less fertilizer is needed if it has a grade of 30% N than another fertilizer that has a grade of only 5% N. How
can one determine this? A simple calculation will give you the answer:

\[
\text{Recommended lb of N per 1000 ft}^2 \times 100\% \quad \text{lb of fertilizer to be applied to 1000 ft}^2 \\
\text{percentage N in fertilizer bag}
\]

For example:

It is typically recommended that you apply 1 lb of N per 1000 ft².

How many pounds of a 30-4-4 fertilizer are required to meet the recommendation?

\[
\frac{1 \text{ lb N per 1000 ft}^2 \times 100\%}{30\% \text{ N in fertilizer bag}} = 3.33 \text{ lb of 30-4-4 fertilizer per each 1000 ft}^2
\]

We can take this process one step further to calculate the total amount of fertilizer needed for an entire turf area. For example, if a half-acre turf lot is to be fertilized using the recommendation above, how much fertilizer is needed for the half-acre lot?

There are 43560 ft² in one acre, therefore a half-acre is half of 43560 ft² = 21780 ft².

If 3.33 lb of 30-4-4 is required for each 1000 ft², then the total amount required will be:

\[
\frac{21780 \text{ ft}^2}{1000 \text{ ft}^2} \times 3.33 \text{ lb} = 72.5 \text{ lb 30-4-4}
\]

If the fertilizer comes in 50-lb bags, then approximately 1.5 bags (72.5 ÷ 50) should be spread over the half-acre lot which will supply 1 lb N/1000 ft².

Nitrogen Fertilization Timing

There are specific times of the year that nitrogen fertilizer should be applied. Fertilizer applications should be timed to maximize growth and vigor in the grass plant. Key times to apply fertilizer are spring, late spring, and late summer or early fall. However, it is not necessary to apply fertilizer several times a year or even at all. Lawns with high populations of fine leaf fescues should be fertilized only once per year or not at all. Lawns, with large populations of Kentucky bluegrass, generally require 2 to 4 fertilizer applications per year.

Timing of fertilizer application should be based on environmental conditions and coincide with turfgrass needs. Therefore, time the fertilizer application to provide nutrients at the beginning of periods when temperature and moisture conditions favor active turfgrass growth. Heavy N fertilization should be avoided when turf is stressed or with shaded turf. Summer application of fertilizer is generally not recommended because most lawns composed of cool-season grasses enter a stage of dormancy. Unless a lawn is irrigated regularly (See chapter 6 under the “Irrigation” section), it enters a period of dormancy as a survival mechanism. Dormant turfgrass does not grow and, therefore, does not need fertilizer.

Midsummer N fertilization application rates above 0.5 lb N/1000 ft² can be detrimental to cool-season turf because it promotes certain hot-weather diseases such as brown patch and summer patch. It also stimulates shoot growth, which depletes the food carbohydrates in the grass. This reduction in carbohydrates is detrimental to root growth. A rapid reduction in root growth leads to decreased heat, drought, wear and pest tolerance.

The focus of turfgrass fertilization is more N in the late summer/early fall and less N in the spring. Late-season N fertilization for cool-season turfgrasses has been advocated anywhere from mid-September to mid-December to promote root growth, better color retention in the fall, and earlier green-up in the spring. Late-season N fertilization of cool-season turfgrasses has become a well-established management practice in the Northeast. The rationale behind this practice is based on the beneficial physiological and rhizome/rooting responses of turfgrasses during this period to the applied N. Current research at the University of Connecticut is showing that there is no added benefit to turf quality when fertilizer is applied past October. Fertilizing past October, however, increased the loss of N by leaching.

The positive response of turfgrass to late-season fertilization is physiologically based and related to energy partitioning within the grass plant under decreasing photoperiods and temperatures.

- During the fall, air temperatures are not optimum for shoot growth but soil temperatures are ideal for root and rhizome growth. However, N from fall fertilization enables the turfgrasses to retain leaf color (chlorophyll content) into late fall and, as a result, higher levels of photosynthesis are sustained. Because air temperatures are not conducive for shoot growth at this time, the energy produced is used for root/rhizome growth.
- Higher photosynthetic rates and minimal shoot growth in the fall maintains higher storage of carbohydrate reserves in the roots. High levels of carbohydrate reserves in the roots enhance winter survival and spring recovery. This enhanced carryover effect on spring green-up and growth substantially diminishes the need for early season N, which would stimulate top growth at the expense of root development.
- Other reported beneficial effects of late-season fertilization is that turf is more vigorous and less susceptible to diseases during spring regrowth, and the turf enters the summer heat period in a more hardened, healthy state.

There is a misconception that late-season fertilization of lawns in Connecticut refers to a mid- to late-November application or later. While a Thanksgiving application of N
to turf in Maryland or Virginia may be a perfectly reasonable practice from both a turf physiological and N utilization standpoint, it may be of little physiological value in more northerly climates such as in southern New England. Studies in Rhode Island during the early 1970s indicated that N fertilization of Kentucky bluegrass until November 1 provided good turf color throughout the fall, but fertilization after November 1 was too late for any significant chlorophyll production or maintenance of color. There are no other published data showing benefits of late-season fertilization past the end of October in Connecticut or southern New England.

Although agronomic benefits of late summer/early fall N fertilization are reported, little is known regarding the fate of N when applied too late in the season. Popular perception is that late-season fertilization of turf poses little or no threat to water quality because it stimulates rooting and rhizome activity, which is sufficient to capture the applied N. But caution should be used with this practice. Leaching losses of soluble forms of N are much higher during this time of the year than during the active growing season.

Also, cool-season turfgrass species and cultivars differ substantially in their N uptake and use efficiencies. Fall or winter fertilizer application might further enhance the leaching potential of some grasses that inherently express poor N-use efficiency. Research conducted at the University of Connecticut indicates that there is greater potential for nitrate leaching losses with soluble N-based fertilizers than with slow-release or natural organic fertilizers when applied in the late-season (after October 21). The author has observed leaching losses of up to 30% of soluble N sources when applied to turf managed as a residential lawn in late October and beyond.

For this reason, we suggest that N fertilizers be applied to turf no later than the end of October, and that most of the N applied during this period should be in a slow-release or controlled-release form.

Heavy spring applications of N to turf are also not recommended. Heavy application of N in early to mid-spring on cool-season turf may encourage more severe incidence of spring and summer diseases and reduce root development. During the winter, stored food carbohydrates (energy sources) are utilized by the grass for maintenance. Because environmental conditions do not favor rapid replenishment through photosynthesis during the winter, the grass enters a very vulnerable position by the time spring regrowth is required. Energy stores are their lowest levels and excessive demands for energy by growth can severely weaken the grass. Heavy N applications in the spring stimulate very rapid shoot growth at the expense of the roots. This results in a weakened turf that is more susceptible to stresses and pests and thins out during the summer. Suggested N fertilizer rates and application times for Connecticut are shown in Table 3-1 above.

<table>
<thead>
<tr>
<th>Turf System</th>
<th>Total annual lb/1000 ft</th>
<th>Time of Application*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky bluegrass, perennial ryegrass with clippings removed</td>
<td>3-4</td>
<td>May 1</td>
</tr>
<tr>
<td>Kentucky bluegrass, perennial ryegrass with clippings returned</td>
<td>2-3</td>
<td>May 1</td>
</tr>
<tr>
<td>Fescues (turf-type tall and fine leaf) with clippings removed</td>
<td>2-3</td>
<td>May 1</td>
</tr>
<tr>
<td>Fescues (turf-type tall and fine leaf) with clippings returned</td>
<td>1-2</td>
<td>May 1</td>
</tr>
</tbody>
</table>

*Apply no more than 1 lb N/1000 ft² at one time when using a fast-release form. N rates can be doubled if slow-release or natural organic forms are used, but reduce the number of times the fertilizer is applied by half.

*Combination fertilizer and pesticide products are not recommended because of the potential for over application of pesticides to areas where there is little or no pest problem. Pesticides should only be used when a documented problem exists and the pesticides are appropriate for that problem.

- Where fertilization is performed only once annually, it is best to apply the fertilizer in late summer to early fall.
- If fertilized twice a season, the fall application should be followed by a second application the following spring.
- Apply no more than 1 lb of N/1000 ft² in any one month.
- Split an annual rate of 2 lb/1000 ft² per season by applying 1 lb in May and 1 lb in September.
- Split an annual rate of 3 lb/1000 ft² per season by applying 1 lb in May, 1 lb in September and 1 lb in October.
- It is unlikely that 4 lb of N/1000 ft² per season will be needed, but if you apply this much N, it is recommended that you split the amount by applying 1 lb in May, 1 lb in June, 1 lb in September and 1 lb in October. Avoid N application before anticipated heavy rainfall (>1 in.). Current weather forecasts should be checked prior to fertilization.
PHOSPHORUS

Turfgrasses take up P primarily as orthophosphate (\(\text{H}_3\text{PO}_4\)). Although many mineral soils contain relatively large amounts of P, it occurs in forms not available to turfgrasses. Phosphorus is readily fixed by Ca, Fe or aluminum (Al). At a pH below 5.5, Fe and Al form an insoluble complex with P that makes P less available to turfgrass. At a pH above 7.5, Ca combines with P to form an insoluble complex that makes P less available to turfgrass. It is commonly believed that P is most available to turfgrasses when soil pH is between 6 and 7.

The role of P in turfgrass culture is important in seed germination, seedling vigor and rooting responses. Therefore, P is critical during turfgrass establishment. Fertilization of P should be based on soil tests or tissue tests. When establishing a new turf, P should be applied when the soil test extractable P levels are low based on the Modified Morgan test (see details on page 24). The P-containing fertilizer should be incorporated into the soil before seeding or sodding to a depth of 4 to 6 inches to provide at least 2 lb \(\text{P}_2\text{O}_5/1000\text{ ft}^2\). On low P sites, the new seedlings or sod should be additionally topdressed to provide at least 1 lb \(\text{P}_2\text{O}_5/1000\text{ ft}^2\) after emergence. With tissue tests, adequate P is available when leaf P concentrations are 0.2% or above on a dry weight basis. For mature turf, P should be applied as a maintenance fertilizer only when extractable soil test P levels read low to provide at least 1 lb \(\text{P}_2\text{O}_5/1000\text{ ft}^2\).

A single application usually provides sufficient P for turfgrass growth for a growing season. There is little turfgrass response to P fertilizers when soil test extractable P levels are medium or above. Continued fertilization of soils testing medium or above for extractable P results in high soil P levels with no added beneficial responses for turf. Indeed, high P soil test levels increase the potential for annual bluegrass infestations on high maintenance turf, leading to a decrease in turf quality. Annual bluegrass imparts off colors in turf, produces unsightly seedheads, and is prone to water stress and numerous diseases and insects (see chapter 7 on page 55). Soils testing high in extractable P also increase the potential for nutrient contamination of surface and ground water by P that leaches or runs off turf.

Fertilization with P is often dependent on N rates. Low maintenance turf with low N input, will probably not require P fertilization. Under higher N inputs with clippings removed, however, P fertilization may be required. Studies at UConn have indicated a P response by turfgrasses only when soil test P was low and N was applied at rates above 2 lb/1000 ft² per year. If clippings are returned to the turf, however, there may be little need to fertilize with P. The residual supply from previous or initial P applications in addition to the recycling of P from the clippings may be adequate for turfgrass needs, provided that the soil pH ranges between 6 and 7. Since P moves slowly through the soil profile, it usually accumulates near the soil surface.

Therefore, application of P fertilizers after core aeration helps move P into the turf rootzone.

Most P fertilizers are derived from rock phosphate ores that are treated with mineral acids. Superphosphate (20% \(\text{P}_2\text{O}_5\)) is derived from rock phosphate treated with sulfuric acid to form calcium phosphate and gypsum (\(\text{CaSO}_4\)). Triple superphosphate (46% \(\text{P}_2\text{O}_5\)) is derived when rock phosphate is treated with phosphoric acid to form calcium phosphates. Ammonium phosphates are derived when ammonia is treated with phosphoric acid to form mono- and diammonium phosphates (50% \(\text{P}_2\text{O}_5\)).

POTASSIUM

Turfgrasses take up large amounts of K as the cation K+.

Turfgrass leaf concentrations of K can range from 2% to 5% of the dry matter. High K concentrations in turfgrass leaf tissue have been reported to improve heat, drought, cold, disease and wear tolerance. It is common to see high-K containing turf fertilizers, which are often called “Winterizers,” promoted for late-season application. However, benefits of high K applications have been inconsistent and not observed in all cases.

Fertilization of K should be based on soil tests or tissue tests. Potassium should be applied only when the soil test extractable levels are low and at a rate to provide up to 1 lb \(\text{K}_2\text{O}/1000\text{ ft}^2\). Tissue concentrations below 1% are considered deficient and a N:K ratio of 2:1 in the tissue is considered optimum. There is little turfgrass response to K fertilizers when soil test extractable K levels are medium or above. Potassium is a constituent of many soil minerals and weathering of nonexchangeable forms may provide a significant amount of K to turfgrasses in Connecticut soils. In fact, there have been few positive effects from K fertilization of turfgrass to date in UConn studies. If clippings are returned to the turf, there is probably little if any need to fertilize with K.

In addition to clipping management, fertilization with K is often dependent on N rates. Low maintenance turf with low N input will probably not require K fertilization. Release of nonexchangeable K from soil minerals will probably be sufficient to meet turfgrass needs under these conditions. Under higher N inputs with clippings removed, however, K fertilization may be required if clippings are removed over many years. When K fertilization is needed under these situations, it is typical to use equal amounts of N and K. If no N is needed, then there is little need for K as well.

Most K-containing fertilizers are derived from potassium salts such as muriate of potash (\(\text{KCl}, 60\% \text{K}_2\text{O}\)). Combining KCl with sulfuric acid forms potassium sulfate (50% \(\text{K}_2\text{O}\)), whereas KCl combined with nitric acid forms potassium nitrate (44% \(\text{K}_2\text{O}\)). Muriate of potash has a higher burn potential (salt effect), but is fast acting and less expensive than most other K-containing fertilizers. Potassium sulfate is slower acting and more expensive.
than KCl and produces an acidifying effect in the soil, but has a lower burn potential than KCl. Potassium is susceptible to leaching in sandy soils with low CEC. Therefore, overwatering of turf should be avoided to maintain adequate levels and reduce loss of K in the soil.

**OTHER ELEMENTS**

Fertilization of turf with nutrients other than N, P and K is not normally required in Connecticut. Calcium and Mg are supplied with liming materials and are rarely found to be deficient for turfgrasses. Generally, there is no need to specifically supply other essential elements than those already discussed (N, P, K), unless there are unique situations. With respect to the micronutrients, deficiencies can be induced when turf is grown on sandy sites with high organic matter content and are over-limed. The alkaline pH induces the formation of insoluble complexes with the micronutrients that make them less available to turfgrasses. Otherwise, there is little advantage in supplying micronutrients to turf in most situations to correct for a deficiency problem.

Although not deficient in most Connecticut soils, Fe (iron) applications to turf in combination with N can produce a dark green color that may increase visual color quality. In these instances, N rates can be reduced from 25% to 35% without a reduction in quality. This is a desirable fertilization practice especially where there are environmental concerns with N losses. A foliar application of Fe at a rate of 2 to 3 oz of ferrous sulfate (0.25 lb Fe/1000 ft²) is probably adequate to produce the desired results. Do not make a foliar application of Fe sulfate if rain is forecast, and do not irrigate for at least 3 to 4 hours after application to allow for uptake by the leaf blades. Chelated Fe can be used at lower rates (0.1 lb Fe/1000 ft²), but this material is more expensive. Chelated Fe can also be applied and watered into the soil. This method may provide a longer lasting response than foliar application.

**COMBINATION FERTILIZERS AND PESTICIDES**

A number of commercial fertilizers are sold that mix fertilizers with pesticides (insecticides or herbicides). The "4-step programs" and "annual lawn programs" by various fertilizer marketers are common examples. This leads the homeowner to apply step 1 during spring, step 2 in late spring, step 3 in summer, and step 4 in the fall. These "step" programs are not necessarily environmentally correct in that some of them are combined with a pesticide, and not every lawn needs a pesticide at the same time fertilizer is applied. Often, it is best to purchase fertilizer only, and purchase the specific pesticide separately if needed. Most lawns do not have pests on every square inch, and broadcast applications promote spreading pesticides across the entire turf area.

The authors believe that use of such products is unwarranted in most turf situations. Often, most turf insects and weeds occur in patches and spot applications will control the problem. With combination products, broadcast applications of the fertilizer and pesticide are made over the entire turf area. While this may be desirable because nutrients are usually required in the same amounts across the entire turf area, application of pesticides to nonproblem areas is without justification and only increases the threat to water quality if the pesticide runs off or leaches. Additionally, there is an increase in potential herbicide injury to ornamental trees and shrubs adjacent to turf areas when combination products are applied.

**Therefore, in accordance with IPM practices, pesticides should be applied only as targeted treatments rather than in a general broadcast manner. Often, it is best to purchase fertilizer only and purchase the specific pesticide separately. Remember that IPM uses pesticides only when and where they are needed.**

**COMPOSITE FERTILIZERS**

A recent trend in fertilizer technology is the development of fertilizers that combine N, P and K (and sometimes micronutrients) into a homogeneous, composite granule. It is reasoned that such composites have a more uniform distribution of nutrients across the turf than bulk blended fertilizers that contain separate nutrient granules. Bulk blended fertilizers are a mixture of different materials of different granule shape, size and density. Segregation of these granules occurs during shipping, mixing, loading and spreading operations because of the particle differences. Consequently, uniform distribution of the individual nutrient granules in bulk blends is difficult to achieve. Uneven distribution of nutrient granules within the spreader throw may result in uneven growth, lack of uniform color and increased management problems. By contrast, it is reasoned that homogeneous composite granules allow for a more even spread of nutrients during application and increased nutrient utilization by the turf.

The **Performance Index Number (PIN)** is being used to provide a performance measurement of composite fertilizers. The PIN is given as a single value and indicates the percentage of particle dispersion (P), integrity of the particle (I) and the nitrogen activity index (N). Values for each component range from 0 to 100. Therefore, the highest possible total PIN of a composite granulation fertilizer is 300 (100 for P, 100 for I, and 100 for N). The implication is that the higher the PIN, the higher the quality of the composite fertilizer. There is little evidence to date, however, to substantiate acceptable minimal PIN values.

The particle dispersion value measures how quickly water breaks the product down into smaller particle sizes after application. The smaller the particle size, the more quickly it breaks down when in contact with water, and the less likely it will be picked up by mowers. The particle integrity value measures the product hardness. The harder the gran-
ule, the less likely it is to break down during mixing, shipping, handling and application. This results in less breakage and less dust being produced. The nitrogen activity index value measures the amount of available WIN (see previous discussion). Some commercial examples of composite fertilizers are Lebanon’s IsoTek31 and Country Club, Scott’s Contec and Andersons’ Tee Time.

**Fertilizer Application Methods**

It is important to apply fertilizer and lime evenly to the turf. Spotty or streaked responses after fertilization indicate improper application. Poor application reduces the efficacy of the nutrients—too little results in poor growth, too much results in injury or nutrient losses. Granular fertilizers are typically applied by using various types of spreaders. The **drop spreader** is basically a large, wide hopper attached to wheels, where the fertilizer exits through a series of openings at the base of the hopper (photo 3-4). The size of the openings can be adjusted to provide the desired rate. Most drop spreaders have rods within the hopper that turn with the wheels to ensure that the fertilizer moves through the openings. These spreaders are very accurate and offer uniform application rates of fine to coarse fertilizer granules. Problems that can be encountered with drop spreaders include misses between passes or excessive overlapping with each pass which produces streaks or stripes due to under or overapplication. This is particularly apparent when N fertilizer is misapplied (photo 3-5). Some drop spreaders have a limited width of distribution which increases the time involved in fertilization. This is more common with the push spreaders. Others have a wide distribution width and are pulled with a vehicle. Drop spreaders are not as easy to maneuver around trees and shrubs as rotary spreaders.

The **rotary** or **cyclone spreader** is a large cylindrical hopper attached to wheels (photo 3-6), and has an impeller (plate) at the base of the hopper that spins as the wheels turn (photo 3-7). The impeller throws out the fertilizer in a semicircular pattern. Fertilizer application is fast with rotary spreaders and large areas can be covered quickly. The rotary spreader, however, is not as accurate as a drop spreader because the distribution pattern of fertilizer spread is not as uniform. The heavier fertilizer granules are propelled farther than the smaller, lighter granules, which results in an uneven spread. Often, it is necessary to overlap the passes to even out the spread or to apply 1/2 the amount in one direction and the other 1/2 in a perpendicular direction. Windy days also affect the spread pattern of rotary spreaders. Therefore, it is best to use these spreaders on calm days. Rotary spreaders usually give better distribution on sharp turns.

**3-5:** Poor application of fertilizer. The light-colored turf received no fertilizer.

**3-6:** A rotary spreader.

**3-7:** Closeup of a rotary spreader.
because they tend to cover a broader swath and fan the fertilizer out at the edges of the swath.

A pendulum spreader is a large hopper with a spout at the bottom of the hopper that moves from side to side throwing the fertilizer out as it oscillates back and forth. These are usually large units that are pulled by a tractor or turf vehicle. The large capacity hopper allows for turf areas to be fertilized quickly.

Regardless of the fertilizer spreader used, avoid fertilizer application on driveways and sidewalks; and near road surfaces, drainage culverts, ponds, streams and lakes. Fertilizer spread on impervious surfaces is prone to runoff and is carried to receiving waters where it can contribute to nutrient contamination problems.

Liquid fertilizer spreaders are available where soluble or suspended fertilizers are applied in a liquid form as a spray. This type of application is most commonly used in a spoon-feeding program or to correct acute nutrient deficiency problems. In these cases, low spray volumes (0.5 gal/1000 ft²) and low rates of fertilizers such as 0.125 lb N or Fe/1000 ft² are applied. Liquid fertilization is becoming more popular with lawn care companies and golf courses. In these instances, higher spray volumes are used (3 to 5 gal/1000 ft²) and fertilizers are often mixed with pesticides. Liquid fertilization is usually less costly than granular fertilization, but initial equipment costs may be higher, particularly if spray equipment is not already available.

**Calibration of Fertilizer Spreaders**

Calibration is the process of determining the amount of fertilizer that is applied by a fertilizer spreader over a turf area. If your soil test recommends that N, P or K fertilizer be applied, it is important that you calibrate your spreader to apply the correct amount of fertilizer. There are various grades of turf fertilizers that do not always contain the same amounts of nutrients or are of the same granule size. Therefore, the same setting on the spreader is not appropriate for different fertilizer grades. (See Appendix D on page 109 for detailed steps on spreader calibration.)

**SOIL REACTION AND TURFGRASS LIMING**

Maintaining soil pH within certain tolerances plays an important role in turfgrass growth and quality. Nutrient availability and soil flora and fauna activities are closely associated with the pH of the soil. These activities are important for mineralization of soil organic matter, thatch and grass clipping decomposition, severity and incidence of certain turfgrass pests, and influences on pesticide efficacy. Liming does not replace a sound fertilization program, but enhances one. Therefore, the turfgrass manager must understand and appreciate how pH influences the persistence, growth and quality of turf.

Soil pH is the result of the chemical reactions that occur in the soil and these reactions affect the degree of acidity or alkalinity of a soil solution. The pH scale is used to measure the effects of these soil reactions. This scale is related to the amount or concentration of hydrogen ions [H⁺] that is present in the soil solution, and then transformed into a value that is easily understood. Mathematically, the pH value is calculated as the negative logarithm of the hydrogen ion concentration [H⁺], and ranges from 0 to 14. (Below 7 is acidic; 7 is neutral; and above 7 is basic.)

Because the scale is measured using logarithms (base 10), it increases or decreases 10 times for each unit change of pH. For example, even though a pH of 5 does not seem that much lower than a pH of 6, the pH of 5 is 10 times more acidic than the pH of 6. A pH of 4 is only 2 units lower than 6, but 100 times more acidic! The following shows how pH of the soil solution is actually calculated:

- The concentration of H⁺ in the soil solution is determined to be 0.00001 moles of H⁺ per liter of the soil solution.

- pH is the negative log₁₀ of the [H⁺] or can alternately be expressed as \[ \log_{10} \frac{1}{[H^+]}. \]

- The log₁₀ of 0.00001 = −5; the negative log₁₀ = −(−5) = 5

Therefore, the smaller the [H⁺] value is, the less acidic the solution (more basic). With acidic soils such as in Connecticut, the turf manager strives to make the H⁺ concentration in the soil solution smaller, which results in a higher pH.

Soil pH varies throughout Connecticut, but most turfgrass soils are in the pH range of 4.5 to 8.0. The soil pH is usually a function of precipitation where greater precipitation or irrigation induces more leaching of Ca⁺², Mg⁺² and K⁺, which are replaced by acidic H⁺ or Al⁺³ ions. Soils of Connecticut, which are located in a humid region of the country and receive about 45 inches of precipitation yearly, generally have acidic soils. On the other hand, dry, arid regions of the country generally have alkaline soils.

Other factors also influence soil pH. The underlying parental material from which soil is formed will affect pH. Most soils of Connecticut are formed from gneiss, schist or granite that are naturally acidic. However, there are small pockets of limestone in the northwestern part of Connecticut and these soils have a more neutral or slightly alkaline pH, even though precipitation is high. Soils high in organic matter also tend to have an acidic pH because organic acids are released from the organic matter as it decomposes.

Fertilization practices may also affect soil pH. Nitrogen applications generally have an acidifying effect (especially the NH₄-based formulations) because H⁺ ions are released when NH₄ is reduced to nitrate (NO₃⁻) in the soil solution.
Optimum Ranges of Soil pH for Turfgrasses

Although most turfgrasses can tolerate a wide range of soil pH values, a pH range of 6 to 7 is generally recommended for Connecticut turf (photo 3-8). Kentucky bluegrass, a popular turf species, does best when soil pH is between 6.5 and 7.2. Ryegrasses and bentgrasses are somewhat more tolerant of lower soil pH values than Kentucky bluegrass, but they also perform best under a neutral or slightly alkaline pH. The fine fescues and turf-type tall fescues can tolerate fairly acidic soil conditions, but their growth is also better under a neutral or slightly alkaline pH.

At extreme pH values, certain essential elements become less available and others become more available (excessive). Many of the micronutrients remain available at acidic pH, which can create problems with Al and/or Mn toxicities. At acidic pH, there is also a decrease in microbial, earthworm, and other soil flora and fauna activities. This results in a decrease in mineralization and decomposition of organic matter, and a potential loss in favorable soil structure and excessive thatch buildup.

Liming Materials

When soil pH is acidic, the turf manager needs to neutralize the soil acidity by adding liming materials. The most common liming materials are:

**Calcitic limestone (calcite):** calcium carbonate (CaCO₃) which is 40% Ca and called agricultural grade limestone.

**Dolomitic limestone (dolomite):** CaMg(CO₃)₂ which is 27% Ca and 13% Mg and also called agricultural grade limestone.

The rate at which CaCO₃ and CaMg(CO₃)₂ are applied to correct acidity depends upon the purity of the material and how fine the material is ground. The purer and more fine the particle size, the faster it neutralizes soil acidity.

The actual range of particle sizes must, by law, be stated on the liming material label. Soil test recommendations assume that the liming materials meet these minimum standards. There is generally little or no advantage in using liming materials that are much finer than the minimum standards.

There are other liming materials available:

**Pelletized lime:** small limestone particles in pellet form. This reduces dust and makes spreading easier. It dissolves rapidly into powder when it comes into contact with water. Due to its ease of application, pelletized lime is commonly used for home lawns by both homeowners and professionals.

**Fluid lime:** very small limestone particles suspended in water and sprayed on turf. This can raise soil pH one unit in several weeks if the soil is moist and warm. Often used by lawn care companies.

3-8: Poor lime application. Green turf pH = 6.3; light green pH = 4.5.

**Burned lime or Quicklime:** CaO or MgO, which has the fastest reaction in the soil, but can burn the turf if applied incorrectly. It is caustic to handle and more expensive than ground limestone. Typically not recommended for turfgrass.

**Hydrated lime or Slacked lime:** Ca(OH)₂ or Mg(OH)₂, which is fast acting but also caustic to handle. It is more expensive than ground limestone, and can react with ammonia-containing fertilizers to form ammonia gas that is toxic to grass. Therefore, do not apply this material and fertilizer at the same time. Wait at least 2 weeks between applications of fertilizer and hydrated lime. However, it is typically not recommended for turfgrass.

Calcium sulfate (gypsum, CaSO₄) or magnesium sulfate (Epsom salts, MgSO₄) have no effect on pH.

Rates of Lime Application

The only way to determine if the turf requires lime is by a soil test. Soil samples can be sent to the University of Connecticut Soil Nutrient Analysis Laboratory, the Connecticut Agricultural Experiment Station or a private soil testing laboratory. (See page 23 for contact information.) Soil pH can also be tested by using home test kits. Although accurate for pH measurements, the home test kits normally do not provide meaningful recommendations for the amounts of lime needed, as will the recommendations provided by the state or private labs. Never guess as to how much lime your turf needs. Too little provides inadequate acid neutralization and too much may result in overliming, which may tie up some of the essential micronutrients.

The rate for liming materials is determined partly by soil texture. Soils with more clay and silt require more lime to neutralize acidity than sandier soils. Soils with higher organic matter may require more lime than the same soil type with lower organic matter content.

Because most Connecticut soils contain an appreciable amount of sand, it is best to limit each application of
ground limestone to 50 lb/1000 ft² when applied to the established turf. Higher rates may result in excessive alkalinity near the soil surface before the lime eventually moves downward. This is especially the case with turf containing a thick thatch layer. If more than 50 lb limestone/1000 ft² are recommended based on a soil test, it is best to split the applications at least a few months apart. For example, if 100 lb limestone/1000 ft² is called for, apply 50 lb/1000 ft² in the fall and the remaining 50 lb/1000 ft² the following spring. When establishing new turf, the total limestone requirement may be applied in a single application provided that it is thoroughly mixed into a 4- to 6-inch depth before seeding or sodding.

Calcite and dolomite limestone do not burn turfgrass under most instances, but excessive applications may raise the pH beyond a desirable level. Overliming on sandy soils is a problem because of the low CEC of sandy soils. With the fast-acting liming agents such as burned lime or hydrated lime, application rates are much less than limestone. These fast-acting materials are hazardous to the applicator and can burn (dehydrate) the turf leaf tissue.

**Calcium Carbonate Equivalent**

When lime recommendations are made for turf, they are based on a calcium carbonate equivalent (CCE) of 100% and assume minimum standards for particle sizes have been met. In other words, if a liming recommendation calls for 50 lb/1000 ft², the assumption is that 100% pure calcium carbonate is used, or a material that has the same neutralizing potential as pure calcium carbonate. The neutralizing potential of liming materials is ranked, therefore, according to its CCE value. As might be expected, sources of liming materials vary in their purity and may not be equivalent to 100% pure calcium carbonate. In these instances, the rate of lime applied should be adjusted so that enough liming materials are applied to raise the soil pH to the desired level. The CCE can be used to calculate the actual amount of that particular liming material needed to neutralize the acidity of the soil. To calculate the adjusted amount of lime required, use the following formula:

\[
\text{Adjusted amount of lime material needed} = \frac{\text{Amount recommended by soil test}}{\text{CCE of liming material}} \times 100
\]

For example, the soil test recommendation calls for 50 lb limestone/1000 ft², and the material has a CCE of 85%, then the actual amount of liming material needed would be:

\[
\frac{50}{85} \times 100 = 59 \text{ lb liming material}/1000 \text{ ft}^2
\]

In this case, an extra 9 lb limestone/1000 ft² is required with a material of 85% CCE to increase the soil pH to same level as a material with 100% CCE.

**Lime Moves Slowly Through the Soil**

Lime moves slowly downward in the soil profile but not laterally. Therefore, missed spots are not neutralized. This is usually not a problem during establishment because the liming material is incorporated into the rooting depth (4 to 6 inches) prior to seeding or sodding. Lime applied to established turf moves very slowly into the soil, however, and cannot be worked into soil without damaging the established turf. Movement into the soil is only about 0.5 to 1 inch per year. Surface applications can take 2 or more years to increase the pH of the rootzone to proper levels. Therefore, the turf manager must not allow the pH to drop too low before adding lime. It is recommended to test the soil every 2 years for pH. If the pH drops to 6 or below, then lime should be added. Limestone is very inexpensive and can be spread at any time of the year. However, it should not be applied to turf that is wilted or frosted or when air temperatures are above 80°F. Lime should be applied shortly before rain, or irrigation should be applied after application to wash any lime off the leaves. It is generally better to apply lime in the fall so that it can be worked into the soil by freezing and thawing action and have sufficient time for reaction before active regrowth of turf in the spring. Applying lime after core aeration helps move lime more quickly into the rootzone.

**Applying Lime**

The same spreaders used for fertilizer application can be used to spread lime. Rotary spreaders are generally better than drop spreaders for ground limestone application because the finely ground material tends to bridge over the spreader outlet of the drop spreader. Even with rotary spreaders, frequent stirring in the hopper may be required with finely ground limestone.

**Correcting Soil Alkalinity**

If a soil test shows the soil pH above 8 in a turfgrass system, then the soil pH must be lowered. Often, this is a result of overliming of sandy soils or over application of materials such as wood ashes. The excess sodium (Na⁺), Ca²⁺, Mg²⁺ ions form insoluble complexes with the micronutrients that may induce micronutrient deficiencies. In these situations, the application of S at rates of 3 to 5 lb/1000 ft² should decrease pH to more favorable levels. Sulfur can be applied as elemental S, ammonium sulfate, iron sulfate or potassium sulfate. Calcium sulfate (gypsum) or magnesium sulfate (Epsom salts) have little effect on soil pH, and should be avoided for purposes of lowering soil pH.

**SOIL TESTING FOR TURFGRASSES**

Soil testing plays an important role in a turfgrass nutrient management program. Soil tests measure the soil pH, amounts of available nutrients and other chemical or physical properties such as soil texture, bulk density, porosity, CEC, soluble salts and organic matter. A turf manager
needs to know about the various soil properties so the proper amount of fertilizer and lime are applied to turf area. Too little fertilizer and lime may result in reduced turf quality, vigor, stand persistence and poor tolerances to environmental, disease and insect stresses. Too much fertilizer may increase problems with diseases and insects, reduce environmental stress tolerances, deplete food carbohydrates, increase the potential for nutrient losses off site and increase economic losses due to unneeded nutrients.

The first step in a nutrient management program is to collect a soil sample. Soil samples can be collected anytime as long as the ground is not frozen or excessively wet (this makes it too hard to get a representative sample). Wait at least 2 weeks to sample after a lime or fertilizer application. Also, it is best to take a sample at least 2 or more weeks prior to establishment or renovation of the area. This allows time for test results to be returned so that the appropriate soil amendments and turfgrass can be purchased. Because temperature affects mineralization and weathering of organic matter and parental minerals, it is best to take soil samples the same time each year so that seasonal differences do not confound the test results. A record of soil test results taken at the same time each year gives a clearer picture of the nutrient dynamics in a turf soil when results are compared across years.

When taking a soil test, be sure to take a representative sample. The test recommendations are based on your sample; therefore, the recommendation is only as good as your techniques. You need to get a representative sample from the area, and it is critical that proper sampling procedures are followed. Generally, many samples are taken from one area, mixed thoroughly in a clean pail, and then a subsample is taken from the many mixed samples to represent the area. As a general guideline, take at least 5 to 15 samples per 1000 ft². Collect samples randomly, but do not bias results by sampling in unusual areas – avoid locations that are different from those of the larger area. For unusual areas, it is best to sample those areas separately. Also, sample the areas separately that are fertilized, mowed, irrigated or managed differently. Often a W sampling pattern works best, i.e., walk across the turf area following a path shaped as a W, sampling along the path.

Soil samples can be collected with a variety of sampling devices: soil probes, core samplers, augers, soil profile samplers, shovels, spades or trowels. If a shovel, spade or trowel is used, collect the one-inch-wide slice from the middle of the sample blade. Sample below the thatch layer to a depth no more than 4 inches deep for established turf and 6 inches deep where a new seedbed has been prepared. Remove any verdures (the aboveground portion of the grass that is not clipped off) and thatch. Take a subsample of soil of about one cup from the pail consisting of 5 to 15 well-mixed samples, and place this subsample into a plastic bag (ones with a sealing strip work best; avoid paper bags because they absorb water from the soil and rip when wet). Identify each bag so that you know which soil test result is associated with the turf area from which it was collected. Avoid heating the sample once placed in the plastic bag (a car trunk on a hot day can become very warm) because some chemical changes may occur and erroneous conclusions may be reached regarding the need for fertilizers.

Newly established turf areas should be tested annually for a few years until the nutrient status of the soil becomes stable. For established turf without problems, a soil sample every 2 to 3 years should be adequate. Problem turf areas should be sampled annually until problems are corrected. High value turf areas probably should be sampled yearly because there is little margin for error in these systems.

Soil samples can be dropped off or sent to a testing laboratory, or the test can be performed by using home soil test kits. Connecticut has 3 state testing laboratories – one located at the University of Connecticut (Department of Plant Science Soil Nutrient Analysis Laboratory) and the Connecticut Agricultural Experiment Stations at New Haven and Windsor. The University of Connecticut provides soil sampling information, soil test results and recommendations for turf. Your local County Extension Center can provide information on how to sample your soil and how to submit it to the Soil Testing Laboratory. Prepaid sample bags (nominal charge) and sampling information are available and can be ordered from the Soil Nutrient Analysis Laboratory, 6 Sherman Place, Unit 5102, University of Connecticut, Storrs, CT 06269-5102 (www.soiltest.uconn.edu), from Extension Centers or from the Home and Garden Education Center, 1380 Storrs Road, Unit 4115, University of Connecticut, Storrs, CT 06269-4115. The Connecticut Agricultural Experiment Station does not charge a fee for soil tests.

**Testing of Nutrient Availability and Soil Testing Philosophy**

The ways in which soil test results are expressed varies among soil testing laboratories. Some lab results are expressed on a qualitative basis – low, medium (or adequate) or high; whereas others express results on a quantitative basis – pounds of available nutrient per acre or in units of parts per million (ppm). Soil tests in the United States are traditionally based on the “acre furrow slice,” which is the volume of soil in the upper 6 to 7 inches of the soil profile. Historically, this relates to the standard depth of a plow, and on average this amount of soil is considered to weigh 2 million lb per acre. Using this as a base, it can be reasoned that if a nutrient was reported to be available at 2 lb per acre, then 2 lb of nutrient are available per 2 million lb of soil, or in its simplest form – one ppm. **Therefore, ppm is always 1/2 the value of the pounds per acre; conversely, pounds per acre are 2 times the ppm.** For example, a soil test of 60 lb available P per acre is equivalent to 30 ppm P.
It may be important when interpreting soil tests to understand whether the values are reported in lb/acre or ppm.

Soil test results also differ on how the recommendation is formed. One method of soil test recommendation is known as the **Sufficiency Level of Available Nutrients (SLAN)**. This is the oldest method of soil testing and is used by most university soil testing laboratories in the United States. This method relies on data gathered under field conditions by which response curves are generated for as many turf species and soil types as possible. The underlying principle of the method is that a turf response to added fertilizer is observed when the soil extractable nutrient levels are low, and the response to fertilization becomes increasing small as the soil extractable nutrient levels approach sufficiency. There is a low probability of response to fertilizer additions when extractable nutrient levels are at optimum or beyond.

Soil test recommendations may also be established on the base saturation percentage of the CEC. This method of testing is known as the **Base Cation Saturation Ratio (BCSR)**. It is founded on the concept that an ideal ratio of cations on the CEC sites produces the best plant response. This method tends to be used by most private soil testing laboratories in United States. According to this method, the proper ratio of nutrients in the soil exists when the percentage base saturation is approximately:

- **60% to 65%** Ca
- **10% to 20%** Mg
- **5% to 10%** K
- **5% to 20%** P

Interpretation of these tests often depends heavily on specific ratios - Ca:Mg and Mg:K. According to some, the ideal Ca:Mg ratio for turfgrass should be about 6 to 10:1; the ideal Mg:K ratio should be at least 2:1. When the ratios vary from the proper ratio, then fertilizer applications are recommended to restore the balance. Many turfgrass and soil scientists do not accept the BCSR method on the grounds that there is little or no data to support its use with turfgrass. Under this method, it is possible that additional fertilizer is recommended even though the extractable nutrient levels are high to very high. Therefore, we do not recommend nor support the development of a turfgrass nutrient management program based on this method.

### Extractants

Various extractants are used in soil testing laboratories for Ca, Mg, P, K and micronutrients. Often, the use of a particular extractant is regionally related or dependent on soil type or properties. In New England, soils are generally acidic and low in organic matter, and have a relatively high sand content. For these soils, the **Morgan** (contains sodium acetate) or **Modified Morgan** (contains ammonium acetate) extractants are regularly used for soil tests. The Morgan extractants are weak acids and are appropriate for most types of soils in Connecticut. In the Midwest, where soils have a higher organic matter and silt and clay content, the **Bray 1 and 2** extractants (contains hydrochloric acid and ammonium fluoride) are used for soil testing. These are strong acid extractants. In the mid-Atlantic and Southeast, the **Mehlich 1** (contains hydrochloric and sulfuric acids) and **Mehlich 3** (contains nitric acid and ammonium fluoride) extractants are used for soils containing higher amounts of silt and clay and lower amounts of organic matter. These are also strong acid extractants. For calcareous or alkaline soils in the western United States, the **Olsen** extractant is used and contains sodium bicarbonate.

It is important that the turf manager understands the relationship between the various soil testing extractants and why they produce their results. For example, if the Bray, Mehlich and Morgan extractants are used on an identical soil sample from Connecticut, the results for nutrient availability may not agree. This may be particularly the case for P. Because Bray and Mehlich are much stronger acid extractants than the Morgans, they remove about 10 times more P from the soil than the weak acid Morgan extractants. The Morgan extractants have been identified as appropriate extractants for most Connecticut soils, and estimate the plant available nutrients for these soils better than other extractants. Because of this, turf managers in Connecticut should use caution when soil tests are based on stronger acid extractants than the Morgans. Those recommendations may not be based on soil types common to this region.

Figures 3-1 and 3-2 on pages 26 and 27 are examples of soil tests result from the University of Connecticut Nutrient Testing Laboratory and the Connecticut Agricultural Experiment Station.

### Test Kits

In addition to state and private soil testing laboratories, home soil test kits can be purchased at garden centers, through supply catalogs, or from landscape and turf supply centers. These home kits range from inexpensive to expensive, typically increasing in accuracy and reliability as the cost of the kits increase. The tests usually involve color
reactions, which are compared to a chart. An extracting solution is added to the soil, and this mixture is allowed to react for a specific time period, and then filtered into a glass tube. The extract is then reacted with various reagents for specific nutrients and the resulting color produced from the reaction is then compared to a calibrated color chart. The darker the resulting color from the reaction of the reagent and the soil extract, the higher the availability level of that element. These tests are usually qualitative and express results on a scale from low to high. This information is then used to calculate the amount of fertilizer needed for desired turfgrass growth.

One should be cautious with turfgrass recommendations from home test kits because it is not clear where or how the calibration data for such recommendations were derived. Additionally, home test kits can offer measures of soil N. Again, caution should be used with N tests for turfgrasses because most have not been fully calibrated or are meaningless. The reason for this is because N exists in many forms in a turfgrass system and changes rapidly. Most home kits measure N as nitrate, which is very mobile, and can move out of the rootzone or can be lost by denitrification or leaching. If the C:N ratio in the soil is greater than 30:1, then nitrate can be immobilized by the soil microbes and is less available for turfgrass uptake. Consequently, fertilizer N need for turfgrass is often guided by color, density, clipping yield or other turfgrass growth responses, rather than on a soil test for N that is not reliable.

Other Testing Methods

It has become more common to base turfgrass fertilization recommendations upon tissue testing. With tissue testing, the clippings are analyzed for nutrient concentration and this value is then compared to a critical range indicating deficiency, sufficiency or excess. It is felt that this method is more accurate than a soil test because it measures the concentrations of nutrients actually taken up by the grass rather than estimated from extractable soil values. The following are suggested sufficiency ranges for tissue nutrient concentration of turfgrasses:

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>%</th>
<th>Micronutrients ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2.8-3.5</td>
<td>Fe</td>
</tr>
<tr>
<td>P</td>
<td>0.3-0.6</td>
<td>Mn</td>
</tr>
<tr>
<td>K</td>
<td>1.0-2.5</td>
<td>Zn</td>
</tr>
<tr>
<td>Ca</td>
<td>0.5-1.3</td>
<td>Cu</td>
</tr>
<tr>
<td>Mg</td>
<td>0.2-0.6</td>
<td>B</td>
</tr>
</tbody>
</table>

Soil testing laboratories that also offer tissue testing may use an instrument called a near infrared reflectance spectrophotometry (NIRS). With this instrument, certain wavelengths of light are reflected from a dry, ground tissue sample when exposed to infrared light. The reflected light is measured and compared to a set of calibration curves for known nutrient concentrations. The method is fast and accurate where calibration curves have been developed. With a microwave oven, tissue grinder and NIRS, tissue nutrient status of turfgrass can be monitored on a weekly, if not daily, basis. The information is recorded and can be used to adjust the fertility program almost instantaneously.

REFERENCES


University of Connecticut Soil Nutrient Analysis Laboratory. http://www.soiltest.uconn.edu/


(The major shortcomings of a tissue testing program are that it is expensive relative to a soil test, and there are few actual calibration tests conducted with a wide range of turfgrasses under various use conditions. Until more calibration tests are completed and verified, the above sufficient ranges should be used as relative guidelines only.)
Figure 3-1: An example of a soil test analysis from the University of Connecticut Soil Nutrient Analysis Laboratory.

University of Connecticut
Department of Plant Science
Soil Nutrient Analysis Laboratory, 6 Sherman Place, Unit 5102, Storrs, CT 06269-5102
Phone: (860) 486-4274; Fax: (860) 486-4562.

**GROWER'S ADDRESS**
KARL GUILLARD
W B YOUNG BUILDING
STORRS, CT 06269

**SAMPLE ID**

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>10</th>
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<tbody>
<tr>
<td>LAB ID</td>
<td>8013</td>
</tr>
<tr>
<td>RECEIVED</td>
<td>10/20/00</td>
</tr>
<tr>
<td>REPORTED</td>
<td>10/23/00</td>
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<tr>
<td>SALES AGENT</td>
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</table>

**NUTRIENTS EXTRACTED FROM YOUR SOIL (MODIFIED MORGAN EXTRACTABLE)**

<table>
<thead>
<tr>
<th></th>
<th>VL</th>
<th>L</th>
<th>M</th>
<th>MH</th>
<th>H</th>
<th>VH</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>1047 lbs/acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>279 lbs/acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1 lbs/acre</td>
<td></td>
<td>***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>228 lbs/acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ratings: VL = Very low, L = low, M = Medium, MH = medium high, H = high, VH = Very high.

**LIME AND FERTILIZER RECOMMENDATIONS**

**CROP OR PLANT:** ESTABLISHED LAWN

**LIMESTONE (GROUND, GRANULAR, PULVERIZED OR PELLETED):**
Apply 100 lbs. per 1000 sq. ft. to raise the pH level. Have your soil re-tested in 3-4 years.

**FERTILIZER:**
Apply 20 lbs of 5-10-5 (or similar grade) or 10 lbs of 10-20-10 (or similar grade) per 1000 sq ft in mid-April to mid-May and again in September. Apply the fertilizer only when the grass is dry.

OR
Follow the recommendations for maintenance fertilizers shown on the enclosed sheet and, in addition, apply 9 lbs of 0-46-0 or 20 lbs of 0-20-0 per 1000 sq ft in spring or fall. In subsequent years, follow the recommendations for maintenance fertilizers shown on the sheet.

**COMMENTS:**
Soil texture classification: Sandy loam
Organic content classification: Medium

If you have questions about this report or about any other plant or soil problem, contact the University of Connecticut Home and Garden Education Center, Department of Plant Science, Unit 4115, Storrs, CT 06269-4115, or phone: (877) 486-6271 (toll-free).
**FERTILITY OF SOIL**

**STATE OF CONNECTICUT**

**THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION**

FERTILITY OF YOUR SOIL MEASURED BY THE MORGAN METHOD. A PRODUCT OF RESEARCH AT THIS STATION

---

Roger Fescuin  
17 Hill Drive.  
Oakville, CT 06779

---

<table>
<thead>
<tr>
<th>DATE: 3-20-01</th>
<th>TEST RESULTS--SEE OTHER SIDE FOR EXPLANATION</th>
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</thead>
<tbody>
<tr>
<td>LABORATORY NUMBER</td>
<td>1301</td>
</tr>
<tr>
<td>YOUR SAMPLE</td>
<td>Front lawn (poor growth)</td>
</tr>
<tr>
<td>CROP TO BE GROWN</td>
<td>Turf</td>
</tr>
<tr>
<td>SOIL TEXTURE</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>ORGANIC MATTER CONTENT</td>
<td>Low</td>
</tr>
<tr>
<td>pH</td>
<td>5.0</td>
</tr>
<tr>
<td>NITRATE NITROGEN</td>
<td>Very low</td>
</tr>
<tr>
<td>AMMONIUM NITROGEN</td>
<td>Very low</td>
</tr>
<tr>
<td>PHOSPHORUS</td>
<td>Medium</td>
</tr>
<tr>
<td>POTASSIUM</td>
<td>Very low</td>
</tr>
<tr>
<td>CALCIUM</td>
<td>Low</td>
</tr>
<tr>
<td>MAGNESIUM</td>
<td>Medium</td>
</tr>
</tbody>
</table>

**SUGGESTED TREATMENT IN POUNDS PER 1000 SQUARE FEET**

<table>
<thead>
<tr>
<th>LIMESTONE AMOUNT</th>
<th>125-130 (Apply half the limestone now, the remainder this Fall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FERTILIZER GRADE</td>
<td>25-5-10</td>
</tr>
<tr>
<td>FERTILIZER AMOUNT</td>
<td>4 (April and Sept treatment)</td>
</tr>
</tbody>
</table>
Chapter 4: Turfgrass Species Adapted to Connecticut

Karl Guillard and Edmond L. Marrotte

COOL-SEASON GRASSES

There are several turfgrass species adapted to the climate of Connecticut. Most of these species are classified as cool-season turfgrasses because their greatest rates of growth occur when temperatures are relatively cool (40°F to 75°F) and moisture is abundant. The periods during late spring-early summer and again during the fall provide optimum growing conditions for the cool-season turfgrasses. During the hot and dry conditions of summer, cool-season turfgrasses grow slowly or go semidormant. This is frequently observed in Connecticut when lawns “brown out” during midsummer, but then resume growth towards the end of summer when temperatures drop and soil moisture increases. The major cool-season turfgrass species utilized in Connecticut are the bluegrasses (Poa), fescues (Festuca), ryegrasses (Lolium) and bentgrasses (Agrostis):

<table>
<thead>
<tr>
<th>Bluegrass (Poa)</th>
<th>Fescue (Festuca)</th>
<th>Ryegrass (Lolium)</th>
<th>Bentgrass (Agrostis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky (P. pratensis)</td>
<td>Tall (F. arundinacea)</td>
<td>Perennial (L. perenne)</td>
<td>Creeping (A. palustris)</td>
</tr>
<tr>
<td>Roughstalk (P. trivialis)</td>
<td>Fine Leaf Species:</td>
<td>Annual (L. multiflorum)</td>
<td>Colonial (A. capillaris)</td>
</tr>
<tr>
<td>Supina (P. supina)</td>
<td>Creeping red (F. rubra)</td>
<td></td>
<td>Velvet (A. canina)</td>
</tr>
<tr>
<td>Canada (P. compressa)</td>
<td>Chewings (F. rubra</td>
<td></td>
<td>Redtop (A. alba)</td>
</tr>
<tr>
<td>Annual (P. annua)</td>
<td>commutata)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep (F. ovina)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard (F. longifolia)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bluegrasses**

Kentucky bluegrass is the most commonly used bluegrass for lawns, parks, athletic fields, institutional grounds and cemeteries. It produces extensive rhizomes (underground stems) that spread and form a very dense sod (fig. 4-1). Leaf texture (width of the blade) is fine to medium and color ranges from medium green to dark green. Kentucky bluegrass is wear tolerant and its aggressive rhizomes give this grass excellent recuperative potential. It is cold tolerant and stays green long into the fall and is one of the first grasses to green up in the spring. Under high temperatures and drought stress, however, Kentucky bluegrass goes semidormant without supplemental irrigation.

When established by seed, Kentucky bluegrass is one of the slowest cool-season turfgrasses to germinate and establish, often requiring up to 2 weeks or more for emergence. This grass species usually requires moderate to high inputs of fertility (2 to 4 lb N/1000 ft² per growing season) and water for high quality and persistence. Growth and quality is best under full sun on well-drained soils with good moisture holding capacity. Kentucky bluegrass does not tolerate poorly drained, acidic or salty soils, or heavy shade. The mowing quality of Kentucky bluegrass is excellent and recommended cutting heights are 1 to 2.5 inches. Under hot and dry conditions, the mowing height should be maintained at or above 2 inches. With high fertility inputs, excessive thatch can become a problem for Kentucky bluegrass, so cultivation and topdressing are necessary to reduce thatch. It is commonly used in mixtures with perennial ryegrass and creeping red fescue. Kentucky bluegrass is also compatible in mixtures with “turf-type” tall fescue.

Low input cultivars of Kentucky bluegrass are currently being tested and some are now available. These cultivars persist under lower inputs of fertilizer and water, but the quality of turf is somewhat lower under these practices. Common types of Kentucky bluegrass are also available and these types are non-pedigree forms (i.e. no specific cultivars) consisting of many genetically different types. Common types grow upright and are sensitive to low mowing and are highly susceptible to leafspot diseases. If high turf quality is not important, common types of Kentucky bluegrass can be adequate for low maintenance goals.
Roughstalk bluegrass is somewhat similar to Kentucky bluegrass in appearance but leaf texture generally is finer and color is lighter green. This grass spreads by stolons (aboveground stems), but the sod is weak because the stolons are not aggressive (fig. 4-2). Seed germination and emergence is rapid. Thatch is not a problem for this turfgrass. Roughstalk bluegrass is very shade tolerant, prefers moist soils and can tolerate poorly drained soils. Wear and traffic tolerance, however, is poor. Drought and heat tolerance also are poor and this shallow-rooted turfgrass needs irrigation on dry sites. Roughstalk bluegrass requires 2 to 4 lb N/1000 ft² per season and tolerates mowing heights down to 0.5 inches. Because of its lighter color and tendency to form patches, roughstalk bluegrass generally is not used in mixtures with other turfgrasses.

Supina bluegrass is a recent introduction from Europe that is reportedly tolerant to shade, traffic and low cutting. It is used for lawns, sports fields and golf courses in Europe. In the U.S., the primary use has been on athletic fields in some northcentral states, although it is being marketed for use in parks, golf courses and commercial and residential properties. This turfgrass produces aggressive stolons that impart high density and rapid recuperative potential. Leaf color of supina bluegrass is light green and texture is fine to medium. Seed germination and emergence is faster than Kentucky bluegrass but slower than roughstalk bluegrass. Wear and shade tolerance is excellent, as is tolerance to compacted and poorly-drained soils. This grass, however, requires relatively high amounts of fertility (3 to 4 lb N/1000 ft² per season or more) and irrigation to maintain quality and persistence. Drought tolerance is poor. Preliminary research indicates excellent resistance to snow mold, dollar spot and red thread diseases. Supina bluegrass tolerates mowing heights as low as 3/16 inch. Seed for

Supina bluegrass is expensive and limited in quantity to date. Current research shows, however, that Supina can be seeded at very low rates with Kentucky bluegrass, and under low mowing height and high N input, will dominate the stand in a short time.

Canada bluegrass typically is not used for high quality turf because of its open, stemmy growth, but is suitable for conservation or erosion control purposes. It produces weak rhizomes that impart a low-density turf (fig. 4-3). Leaf texture of Canada bluegrass is similar to Kentucky bluegrass, but color is bluish-green. Canada bluegrass has excellent drought and heat tolerance and is adapted to excessively well-drained, low pH soils. The fertility requirements of Canada bluegrass are low (2 lb N/1000 ft² per season or less). This grass does not need supplemental irrigation once established. Shade tolerance is less than roughstalk bluegrass but better than Kentucky bluegrass. The recommended cutting height for Canada bluegrass is 3 to 4 inches or higher.

Annual bluegrass is often considered a weed in low-cut, irrigated turf, but plant breeders have released improved commercial cultivars for golf course putting greens and tees (Creeping bluegrass). Annual bluegrass can exist in different forms - an annual upright bunch-type form with profuse tillering capacity, or a perennial prostrate, stoloniferous form. Leaf texture is fine to medium and color is light pale-green to yellow green (fig. 4-4). In Connecticut, annual bluegrass is listed as a noxious weed, but it occurs so frequently that management for annual bluegrass persistence is often necessary. Annual bluegrass is tolerant of extremely low cutting heights and can persist on poorly drained, compacted soils. It produces seedheads throughout the growing
Annual bluegrass requires high fertility and irrigation rates and is sensitive to extremes in temperature. Drought tolerance is poor, and thus, unirrigated areas turn brown and die. Annual bluegrass is susceptible to the annual bluegrass weevil (Listronotus maculicollis), which eats the stem, but this weevil is not used as a biological control agent because they produce blemishes on turf. This grass is highly susceptible to anthracnose disease during the mid to late summer. More commercial cultivars of annual bluegrass are expected in the near future that show improved performance characteristics over the wild types (If you can’t beat them, join them!).

**Fescues**

Tall fescue is a coarse-textured, persistent turfgrass with a bunch-type growth habit that also produces short rhizomes under close mowing (fig. 4-5). It is used for lawns, athletic fields, playgrounds, waterways, soil conservation purposes, roadsides, airstrips and fairgrounds. Tall fescue is sometimes overseeded into sports fields where other cool-season turfgrasses do not persist because of excessive traffic. There are different types of tall fescue and these differ in leaf texture, height and color. The older tall fescue types, such as ‘Kentucky 31’ and ‘Alta’ are generally taller and have a very coarse-textured leaf blade and are lighter green in color. These types tend to become clumpy and objectionable when grown in mixtures with other turf species, especially under infrequent or higher cut mowing. Regrowth of the leaf blades of the older cultivars after mowing also tends to be more rapid than the other turf species, which imparts a non-uniform appearance to the turf.

The newer ‘Turf-type’ and ‘Dwarf’ tall fescues are finer in texture, shorter in habit and darker green in color. These types are more suitable for mixtures with Kentucky bluegrass and perennial ryegrass because leaf texture and growth responses are more similar. Rate of seed germination and emergence of tall fescue is less than the ryegrasses but greater than Kentucky bluegrass. Tall fescue grows best under full sun on well-drained, fertile soils, but is tolerant of a wide range of soil and site limitations. Tall fescue is tolerant of low fertility and low pH, and is adapted to poorly drained soils or temporary water submersion. It has high salt tolerance and has the best drought and heat tolerance of all the cool-season turfgrasses, due in part to its deep root system. It is moderately tolerant of shade and shows good wear tolerance and recuperative potential. Tall fescue performs adequately with 1 to 2 lb N/1000 ft² per season on low maintenance areas but responds to 3 to 4 lb N/1000 ft² per season. It has a low thatching potential. Endophyte-enhanced cultivars are available which show increased insect, disease and drought stress tolerance.

Fine leaf fescues are composed of narrow-leaved turfgrass species whose blades resemble a pine needle or a bristle from a hairbrush (fig. 4-6). The fine fescues most commonly used for turf are creeping red fescue, Chewings fescue, sheep fescue and hard fescue. As a group, the fine fescues tolerate shade, low fertility, low pH and droughty soils. They are ideal for low maintenance turf, but do not tolerate poorly-drained or salty sites or areas with high traffic and wear such as sports fields or playgrounds. Fine fescues tend to decline under high rates of nitrogen and irrigation because of competition from other turf species. Under prolonged periods of high heat, humidity and drought stress,
the fine fescues may become semi-dormant.

The fine fescues require 1 to 2 lb N/1000 ft² or less per season. In some instances, atmospheric deposition of nitrogen may be sufficient for the fine fescues in low maintenance areas. Once established, the fine fescues do not require irrigation. Mowing quality of the fine fescues is generally poor because of the tough leaf blades. Shredding and discoloring of the leaf tips frequently occurs in the summer on these grasses when mowed with dull blades. Recommended mowing heights are 2 inches and higher. Fine fescues persist and maintain their quality under infrequent or no mowing. Endophyte-enhanced cultivars of the fine fescues are available.

**Creeping red fescue** produces rhizomes that can form a dense sod. **Strong creeping red fescue** has aggressive rhizome growth, whereas **slender creeping red fescue** has reduced rhizome activity. Strong creeping red fescue has greater spread and recuperative potential than slender creeping red fescue. Leaf color of creeping red fescue ranges from medium to dark green. It is commonly used in mixtures with Kentucky bluegrass and perennial ryegrass. Seed germination, emergence and seedling vigor is generally greater than the other fine fescues. Because of its rhizomes, creeping red fescue tends to produce a significant amount of thatch and requires periodic dethatching.

**Chewings fescue** is a subspecies of creeping red fescue and is very similar in appearance, except that it does not produce rhizomes and has a bunch-type form with vigorous tillering. Most attributes of Chewings fescue are similar to creeping red fescue. Chewings fescue is less tolerant of temperature extremes than creeping red fescue, but it is more tolerant of lower mowing heights. It tends to become tufted under unfavorable soil conditions or low seeding rates. Thatch can become excessive with this species.

**Hard fescue** is a bunch-type turfgrass that is used primarily for reduced maintenance turf areas. It has dark-green leaf color and provides good density once established. Hard fescue is tolerant of low fertility and droughty soils, but is less drought tolerant than sheep fescue. Hard fescue is used more frequently for finer turf areas than is sheep fescue. The major disadvantage of hard fescue is its relatively slow germination and rate of establishment.

**Sheep fescue** is a bunch-type turfgrass used primarily in low maintenance situations such as roadsides, roughs, soil conservation areas and cemeteries. Leaf color is bluish-gray and the leaf blades are stiffer than creeping red fescue or Chewings fescue.

**Ryegrasses**

**Perennial ryegrass** is a fine to medium-textured turfgrass with genetic potential for dark green color. It is utilized in lawns, parks, athletic fields, cemeteries, institutional grounds, golf course fairways and roadsides, and for soil conservation purposes when rapid cover is needed. It is used extensively to overseed thin or worn turf. Perennial ryegrass does not spread vegetatively as it lacks rhizomes or stolons. Growth habit is bunch-type in form with profuse tillering capability (fig. 4-7). Perennial ryegrass germinates and emerges very rapidly (often less than 7 days) and establishes quickly. It grows best under full sun on well-drained, fertile soils with neutral pH and high water holding capacity. On infertile or low pH soils, perennial ryegrass usually becomes thin and clumpy and tends to be more susceptible to rust and red thread diseases.

Perennial ryegrass is compatible for use in mixtures with Kentucky bluegrass and creeping red fescue. It can be very competitive with other grasses, however, and is often limited to 20% by weight of the seed mixture to prevent over-dominance of the stand. Wear tolerance of perennial ryegrass is good but its recuperative potential is not as great as Kentucky bluegrass.

Perennial ryegrass requires moderate to high inputs of fertility (2 to 6 lb N/1000 ft² per season) for high quality and persistence. Drought and heat tolerance are good, but tolerance to shade is poor to moderate. Cold tolerance of the newer cultivars is improved over the older cul-
tivars. Mowing quality of perennial ryegrass is lower than Kentucky bluegrass and the tough veins in the leaf blades tend to shred with dull mower blades, thus reducing turf color quality. Preferred mowing heights for perennial ryegrass is 1 to 2.5 inches, although some of the newer cultivars developed for sports turf can be mowed as low as 0.5 inches. Endophyte-enhanced cultivars are available which show increased insect, disease and drought stress tolerance.

Annual ryegrass is similar to perennial ryegrass in appearance, but leaf texture is usually coarser and the color is lighter green (fig. 4-8). It lacks cold tolerance and generally does not overwinter in Connecticut. Annual ryegrass has the fastest germination and emergence of all cool-season turfgrasses. It is often included in “Contractor’s Mix” to provide rapid ground cover. Temporary turf often contains a high percentage of annual ryegrass. If a permanent turf is the goal, however, annual ryegrass should not be more than 20% of the seed mixture by weight because of its tendency to winterkill. Mowing heights are generally higher for annual ryegrass than for perennial ryegrass. Drought tolerance is lower than perennial ryegrass. Aside from these differences, characteristics and adaptation of annual ryegrass is similar to perennial ryegrass.

Intermediate or hybrid ryegrass is a mixture of many intermediate types resulting from crosses between perennial and annual ryegrass. Performance and characteristics are intermediate between the two.

Bentgrasses

Creeping bentgrass is sod-forming turfgrass that produces aggressive stolons. Thatch potential is high. Leaf texture is fine to medium and color varies from greenish yellow to medium green (fig. 4-9). Creeping bentgrass is used primarily for golf course greens, fairways, tees and outdoor tennis courts because of its tolerance to very low mowing heights. It is not suitable for lawns under normal maintenance practices and is often considered a weed in lawns because it develops in lighter colored, circular patches. Under low mowing, density of creeping bentgrass is high. Recuperative potential and wear tolerance is good, but under low mowing, creeping bentgrass requires frequent irrigation, pesticide applications, dethatching and topdressings. Creeping bentgrass grows best under full sun on well-drained soils with high fertility, but it tolerates poorly drained soils with low pH, moderately low fertility and high salinity. It has fair shade tolerance. Creeping bentgrass responds to nitrogen and typically 2 to 6 lb N/1000 ft² per season are applied to meet performance goals. It tolerates cutting heights as low as 3/16 inch, and cutting heights of 3/4 inch or less result in the best quality. Higher cutting heights result in upright stolon growth and a “puffy” appearance, called false crowns. Creeping bentgrass is very susceptible to injury from many herbicides and is highly susceptible to many diseases.

Colonial bentgrass produces sod-forming stolons and sometimes rhizomes, but growth is not as aggressive as creeping bentgrass (fig. 4-10). This bentgrass has lost favor to creeping bentgrass in recent years, but it is used for golf course greens, fairways and tees where creeping bentgrass is not suited. It can be used for home lawns because it is less aggressive than creeping bentgrass. Colonial bentgrass has better drought tolerance and lower fertility requirements than creeping bentgrass, but is less tolerant of temperature extremes and
salinity. Colonial bentgrass responds to 1 to 2 lb N/1000 ft² per season and requires less irrigation than creeping bentgrass.

**Velvet bentgrass** has the finest texture of all the cool-season turfgrasses. It produces stolons that form a dense sod and has a profuse tillering capacity. Thatch potential is high. Velvet bentgrass is generally restricted to certain specific soil and climatic conditions in New England. It is primarily used as golf course putting greens but can be found in home lawns. Drought tolerance is better than creeping and colonial bentgrass. Velvet bentgrass grows best in full sun on well-drained soils, but tolerates low soil fertility and soil pH better than creeping bentgrass. Shade tolerance is better than creeping and colonial bentgrass. Nitrogen requirements are similar to colonial bentgrass (1 to 2 lb N/1000 ft² per season). Velvet bentgrass requires less irrigation than creeping bentgrass. Like the other bentgrasses, velvet bentgrass is susceptible to most turf diseases and is prone to herbicide injury. Frequent dethatching and topdressing is required to control excessive thatch. Velvet bentgrass is also prone to iron chlorosis. Because of the very fine texture, velvet bentgrass requires a mower with a high frequency of cut for best mowing quality. Seed sources for velvet bentgrass are limited.

**Redtop** produces short rhizomes, but does not form a tight sod (fig. 4-11). It is no longer recommended for lawns and is utilized for conservation, roadsides or erosion control purposes. It has excellent drought tolerance and tolerates excessively well-drained, low fertility and acidic soils. Leaf texture is coarser than the other bent, and color is light gray-green. The seedheads are reddish, which gives this bentgrass its common name. Redtop tolerates low, frequent mowing heights, but growth is best under higher cutting heights.

**Other Cool-Season Turfgrass Species**

Other cool-season turfgrass species are being evaluated for turf purposes and may provide additional choices for turfgrass selections in the near future.

**Alkaligrass** (*Puccinellia distans*), is a recent release which has great salt-tolerance. This grass may be useful near sidewalks or roads where deicing materials are applied during the winter, or near coastal areas where salt spray or storm surges increase the salt exposure to turfgrasses. Alkaligrass has a bunch-type growth habit with potential for medium to high-density turf. Leaf texture is fine to medium and color ranges from gray-green to medium green. Alkaligrass can tolerate cutting heights as low as 0.5 inches, but persistence is probably better with cutting heights from 1.5 to 3 inches. It has medium wear tolerance with fair recuperative potential. Alkaligrass grows best under full sun and well-drained soils with high fertility. In addition to salt tolerance, it also tolerates poorly drained soils with high pH (alkaline) and low to medium fertility. It can be found growing in standing water. Alkaligrass has good cold tolerance and fair shade tolerance, and responds to nitrogen at rates of 2 to 3 lbs N/1000 ft² per season. An undesirable feature of alkaligrass is that seed heads formed in late summer persist into the fall, even at lower mowing heights.

**WARM-SEASON GRASSES**

The other major class of turfgrasses is warm-season turfgrass. Warm-season turfgrasses produce their greatest growth when temperatures are high (85°F or above). The major warm-season turfgrasses used in the U.S. are bermudagrass, St. Augustinegrass, centipedegrass, carpetgrass, bahiagrass, zoysiagrass and buffalograss. Most warm-season turfgrasses are utilized in the South or Southwest. In these regions, high temperatures preclude the use of cool-season grasses to any great extent during most of the year. Cool-season grasses are often overseeded into dormant warm-season grasses, however, during the cooler months in these areas. There are few warm-season turfgrasses adapted for use in Connecticut because they are not tolerant of prolonged freezing temperatures.

**Zoysiagrass** or **Japanese lawngrass** (*Zoysia japonica*) is the only warm-season turfgrass that persists with any regularity in Connecticut under low cutting heights. In fact, this grass is so aggressive it can become a weed problem under certain situations. Zoysiagrass has very aggressive rhizomes and stolons, which produce a dense, green turf during the...
summer when most cool-season turfgrasses are heat stressed or semi-dormant (fig. 4-12). It is primarily used for lawns and if slow establishment and reduced recuperative potential is not objectionable, then zoysiagrass can be used on playgrounds, athletic fields, fairways, tees and other intensively used areas. Leaf texture is medium and color varies from light to dark green. Thatch potential is high and frequent dethatching is required. Rate of seed germination and seedling vigor are slow. Because of this, sprigs or plugs are used to establish zoysiagrass. It may take 2 to 4 years before a solid stand of zoysiagrass is obtained from the time of sprigging or plugging. Wear tolerance is excellent due to the tough, stiff leaves. Zoysiagrass grows best under moderate moisture levels on fertile, well-limed soils, but it can persist under low soil pH and fertility, and is very drought tolerant. It does not tolerate poorly-drained soils. Zoysiagrass performs well under 1 to 2 lb N/1000 ft² per season. The best time to fertilize is in late spring and again in midsummer. Zoysiagrass should be mowed at a height of 0.5 to 1 inch. Zoysiagrass is slow to green-up in the spring and looses color by the late summer when it goes dormant (photo 4-1).

**Buffalograss (Buchloe dactyloides)** is a native grass of the North American Plains (fig. 4-13). Breeders have recently released improved turf-types of buffalograss for arid conditions. This warm-season grass is tolerant to freezing temperatures and may have use in Connecticut. To date, there has been no testing of this species in our climate to confirm its adaptation potential to Connecticut conditions. It produces profusely branching stolons and is used in arid conditions for non-irrigated lawns, parks, cemeteries, sports fields, roadsides and soil conservation areas. Leaf texture is fine and color is grayish-green. Wear tolerance is good and recuperative potential fair due to slow growth rates. Buffalograss is extremely drought and heat tolerant, but goes semi-dormant in severe drought. It tolerates a wide range of soil limitations from infertile, dry soils to temporary water submersion. Shade tolerance is moderate. Turf quality is best under mowing heights of 2 to 3 inches, but buffalograss can tolerate cutting as low as 0.5 inches. Fertility requirements are low and 1 to 2 lb N/1000 ft² or less is adequate. Overfertilization results in decreased persistence and quality of buffalograss. This grass may find use in Connecticut for low maintenance turf.

**SELECTION CRITERIA FOR TURFGRASS SPECIES**

Selection of a turfgrass species depends upon the goals and expected uses for a particular turf. Turfgrass performance and quality are dependent on many factors. For selection of the appropriate turfgrass, the aesthetic value can be evaluated on color, texture and density. Turfgrass leaf color ranges in shades of light green to dark green and is determined largely by genetics. For example, Kentucky bluegrass and perennial ryegrass have genetic potential for darker green leaf color than the bentgrasses. In the United States, we generally prefer darker green grasses, while Europeans prefer medium to lighter green grasses. Color can also be modified to some degree by nutrient management. Timely applications of nitrogen and/or iron deepens the leaf color of most turfgrasses to their darkest genetic potential.

Turfgrasses vary in their growth habit. Some are tall and grow upright (bunch-types), whereas others are short, low-growing, prostrate forms (sod-forming). For example, ryegrasses are considered bunchgrasses because their tiller growth is upright and they do not have rhizomes (underground lateral stems) or stolons (above-ground lateral stems), which are responsible for vegetative spread beyond the main shoots. On the other hand, Kentucky bluegrass has rhizomes that allow this species to spread and fill a turf
area with a thick sod under proper management. Generally, the more upright the growth, the more mowing that is required. Because of the desire for reduced mowing, plant breeders have developed “dwarf” or slower-growing cultivars for some of the upright turf species, such as tall fescue.

When selecting a turfgrass species, there are many factors and characteristics of the turfgrass to consider. Each characteristic or factor is weighted differently depending on desired goals of the homeowner or turf manager. The anticipated persistence and quality of the turf are of primary importance.

The following are most of the important characteristics of turfgrass species used in Connecticut. Tables 4-1 and 4-2 can be used as guides to aid in proper turfgrass species selection for a particular turf site.

**Establishment Rate**

Important when vegetative cover is required quickly. In most cases, there is a need to establish turf as quickly as possible to prevent weed infestation, control erosion or recover from wear or damage.

### Leaf Texture

Describes the width of the leaf blade. Usually finer-textured grasses are preferred over coarse-textured grasses. Typically, grasses with wide textural differences are not mixed together.

### Density

Indicates the ability of a turfgrass species to form a dense sod. Shoot density is directly related to texture and cutting height and frequency. Finer textured grasses have a higher density potential. Lower mowing heights encourage greater density. Grasses with high-density ratings often give the turf a carpet-like appearance.

### Cold Tolerance

Determines winter hardiness and color retention during the off-season. Often, it is desirable for turfgrasses to start early growth in spring, and remain green in the fall. The cool-season turfgrasses generally have better cool-weather color retention and cold tolerance than the warm-season turfgrasses. Zoysiagrass is a warm-season turfgrass that is winter hardy in Connecticut, but it loses the green color in the

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**Table 4-1: Turfgrass Tolerances.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Establishment Rate</th>
<th>Leaf Texture</th>
<th>Density</th>
<th>Cold</th>
<th>Heat</th>
<th>Drought</th>
<th>Shade</th>
<th>Acid</th>
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<tr>
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<td>3-4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2-3</td>
<td>4</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Buffalograss</td>
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Establishment Rate: 1 = Very Slow  2 = Slow  3 = Medium  4 = Fast
Leaf Texture: 1 = Very Fine  2 = Fine  3 = Medium  4 = Coarse
Density Potential: 1 = Low  2 = Medium  3 = High
Tolerances: >1 = Very Poor  1 = Poor  2 = Fair  3 = Good  4 = Excellent
late summer and is slow to green up in the spring. In the South and Southwest, some warm-season turfs are annually overseeded with cool-season grasses to provide green color and non-dormant playing surface during cool months.

**Heat Tolerance**

The ability to retain quality in the hot summer months varies with turfgrass species. The warm-season grasses are much better adapted to higher temperatures than the cool-season grasses. Kentucky bluegrass goes semi-dormant under high temperatures with moisture stress.

**Drought Tolerance**

Drought tolerance is important when irrigation cannot be provided. Many cool-season grasses go dormant or semi-dormant under moisture stress, especially with high temperatures. The water needs of a turfgrass vary with use. For example, water needs are often greater for areas that are exposed to lots of “wear and tear.” Some grasses, like tall fescue, are large water users, but have a deep root system to reach water that other grasses cannot reach. In general, the warm-season turfgrasses have better water use efficiency than cool-season grasses.

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**SHADE PROBLEMS AND CORRECTIVE MEASURES**

One of the most frustrating problems associated with turf care is the constant battle to establish turf in shaded areas. Large quantities of time, effort and money may not rectify the situation. Typical problems associated with a shade environment compared to full sun:

- Reduced light
- Poorer quality light
- Reduced air movement
- Higher relative humidity
- Prolonged wetness following rainfall or irrigation
- Cooler temperatures and reduced temperature fluctuations
- Increased disease problems
- Moss and algae growth
- Competition between trees and grasses for nutrients
- Competition for water, especially from shallow-rooted trees such as maple or beech

Common symptoms of turf grown in shade:

- Thin, narrow and elongated leaf blades
- Reduced rate of leaf appearance
- Reduced tillering
- Poor wearing ability
- Slow recovery after being damaged
- Shallow, weak root system
- More succulent turf

**Defining Shade**

The traditional practice of defining shade as light, medium or heavy, without attaching a value, is almost useless. Therefore, the following values are used for purposes of discussion:

- **Full Sun:** 100% of the daily available sunlight. This is the optimum for good turf development.
- **Light Shade:** Less than 100% but more than 75% of the daily available sunlight reaching a particular area. This range of sunlight should not present a problem for lawn maintenance.
- **Medium Shade:** Less than 75% but more than 25% of the daily available sunlight reaching a particular area. This range is good to fair with the ability to maintain a satisfactory lawn becoming increasingly more difficult as the total available light diminishes to 25%.
- **Heavy Shade:** Less than 25% of the daily available sunlight reaching a particular area. It is very difficult to establish and maintain a lawn at this light level. Choose a more shade tolerant ground cover.

**Cultural Practices for Shaded Areas**

Lawn establishment in a shaded site is more likely to be successful if seeded in late summer (mid-August through September). The area then has the maximum length of time with the leaves off the trees. This should allow good root and tiller development. It is extremely important to continually remove the fallen leaves. Sodding can be done at this time if the sod contains the correct species of grasses. However, most sod is predominately Kentucky bluegrass, which is not well adapted to shade. Once the lawn is established, mow the grass to a height of 2 1/2 to 3 inches. The longer leaf blade has a larger surface to gather sunlight. This results in a stronger plant.

**Reducing the Shade**

It may be possible to establish and maintain a lawn in a shaded wooded site by removing some trees. Trees should be spaced far enough apart for good airflow and light penetration. Forty to 60 feet apart is suggested.

Low branches on trees should be removed to a height of 10 feet or more. This allows more early morning and late afternoon light to enter the area. Thinning the tops of dense trees allows increased light to penetrate to the turf. Thinning is the selective removal of some small and large branches.

In order to avoid the unnecessary sacrifice of trees, these drastic steps should only be considered after all other options have been tried in the particular area.
Shade Tolerance

Most turf areas have scattered trees or structures that impart shade during much or part of the day. Therefore, turfgrass species that tolerate shade are needed for these areas. Most shade tolerant turfgrass species, however, have low wear tolerance. (For more detail, see page 37.)

Tolerance to Soil Acidity

In general, most turfgrasses are reasonably tolerant of low soil pH. Better quality and growth, however, are found under near neutral or neutral pH. There is an interest in grasses that tolerate low pH for low maintenance areas where liming is not feasible or affordable.

Submersion Tolerance

Standing water can occur frequently on turf areas located on flood plains, low spots with poor drainage and slopes adjacent to water.

Salinity Tolerance

High levels of soluble salts are found along roads and sidewalks where deicing materials are used, and near coastal regions with high tidal surges and ocean spray. High inputs of commercial fertilizers also increase salt levels in the soil. Alkaligrass is a recent turfgrass release with a high salt tolerance.

Mowing Height

Due to the detrimental effects of low cut turf (increased weed encroachment, increased evaporation of soil moisture), turfgrasses should not be maintained at the lowest tolerated height. In general, the bunchgrasses are mowed at higher height of cut than the sod-forming grasses. Plant breeders have released new cultivars of Kentucky bluegrass and perennial ryegrass that can be mowed lower than the current recommended heights of cut.

Mowing Quality

The leaf blades of turfgrasses vary in their resistance to clipping. Kentucky bluegrass cuts clean with a sharp blade whereas ryegrasses and fescues have tough vascular bundles in their leaves that resist cutting. The tips of the fine fescues may turn brown when mowed in the summer with dull blades.

Nutrient Requirements

Nutrient requirements vary with species and intended use. Newer turfgrass cultivars are being released that are adapted for lower maintenance and less fertilizer inputs. Excessive fertilization of lower maintenance cultivars may result in serious pest or cultural problems.

<table>
<thead>
<tr>
<th>Table 4-2: Turfgrass Species Characteristics.</th>
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<tbody>
<tr>
<td>Species</td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
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<tr>
<td>Roughstalk bluegrass</td>
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<tr>
<td>Supina bluegrass</td>
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<tr>
<td>Canada bluegrass</td>
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<td>Annual bluegrass</td>
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<tr>
<td>Creeping bentgrass</td>
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<tr>
<td>Colonial bentgrass</td>
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<tr>
<td>Velvet bentgrass</td>
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<tr>
<td>Redtop</td>
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<tr>
<td>Creeping red fescue</td>
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<td>Chewings fescue</td>
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<td>Sheep fescue</td>
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<tr>
<td>Hard fescue</td>
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<tr>
<td>Tall fescue</td>
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<tr>
<td>Perennial ryegrass</td>
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<tr>
<td>Annual ryegrass</td>
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<tr>
<td>Zoysiagrass</td>
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Mowing Quality and Recuperative Potential: 1 = Poor  2 = Fair  3 = Good  4 = Excellent
TURFGRASS NUTRIENT AND INTEGRATED PEST MANAGEMENT

Pest Potential

Diseases, insects and weeds are generally more of a problem with high intensity use turf – typically, pest potential increases with input levels. There is also a direct relationship to cutting height – as cutting heights go down, susceptibility to pest problems rises. Some turfgrasses are more resistant to pests than others. In certain cultivars of ryegrasses and fescues, naturally occurring fungi called endophytes live within the leaves of these grasses. Alkaloids produced by the fungi are harmful to some insects feeding on the leaves and may reduce the incidence and severity of certain diseases. Affected insects include chinch bugs, sod webworms and billbugs, but not subsurface insects such as white grubs. Endophyte-enhanced cultivars also have increased drought stress tolerance and usually have higher turf quality and color ratings. Only seeds transmit the endophyte, and it is best to plant endophyte seed within 2 years of harvest. (For further information on endophytes, see page 101.)

Thatch Tendency

Some turfgrass species develop an excessive accumulation of thatch, which in turn can predispose turf to rapid deterioration. Thatch is composed mainly of dead roots and stems (rhizomes and stolons). Excessive thatch is more prevalent in species having stolons and rhizomes than in bunchgrasses. Thatch problems increase with pesticide use, high nutrient and water input, and with compaction and low soil oxygen conditions. These conditions reduce microbial activity necessary for thatch decomposition. Contrary to popular belief, returning grass clippings to the turf does not increase thatching tendency.

Wear Tolerance

Turfgrass durability is an important trait under intensively trafficked turf – athletic fields, playgrounds, parks, golf greens (especially practice greens) and tees, as well as home lawns. Turfgrasses need to be able to survive the damage from heavy use and still have the ability to replace damaged leaf tissue. Higher wear tolerance is correlated to some extent to wider leaf blade widths.

Recoverative Potential

Recovery from injury is related to growth habit. Those species with aggressive rhizomes and stolons, and/or rapid tillering capabilities have the greatest recoverative potential.

Species Adaptation

Each turfgrass site is a microcosm of every possible combination of environmental influences, cultural input practices, soil conditions and interaction with other plants and turf pests that can be imagined. So it is logical that one species of turfgrass will not tolerate nor persist across the extremes of site conditions found in any Connecticut lawn. For this reason, most turfgrass seed is typically sold in mixtures containing several turfgrass species and/or cultivars within a species. The expectation is that at least one or more of the grasses in the mixture is adapted to the various conditions that are present on the site, therefore, avoiding an establishment failure. Potential for failures increases when only a single species or cultivar is sown.

A good seed mix for most home lawns in Connecticut should consist of improved cultivars of Kentucky bluegrass, fine-leaf fescue and improved perennial ryegrass. A mix of 30% to 45% fine-leaf fescue and 30% to 40% Kentucky bluegrass, with no greater than 20% perennial ryegrass, provides an excellent lawn for most Connecticut conditions.

The major reason for turf failure in Connecticut and elsewhere is improper match of site conditions to adapted turfgrass species – Kentucky bluegrass will not persist in every turf site! Therefore, it is imperative that one evaluate the site conditions before establishing turfgrasses. Repeated failure to establish a turfgrass in particular spots in the turf area usually indicates an improper match between the turfgrass selected and site conditions present, or with the management practices used on the turfgrass.

CULTIVAR SELECTION

After choosing the best-adapted turfgrass species to the site conditions, one must choose an appropriate cultivar as well. Like differences in species, not all cultivars within a species respond to the same conditions. With over 600 turfgrasses currently available for purchase in the U.S. and several hundred more in various stages of development, how does one decide which is the “best” turfgrass to use at any particular site? There are a few ways to answer this question.

First, if one has had good experience with a particular cultivar on your site, then this cultivar should continue to perform well in the future unless conditions or turf care practices have changed. Local or regional suppliers of turfgrass seed also should have a reasonable amount of feedback for a particular cultivar or mixture and will provide this information if asked. More than likely, however, seed suppliers often recommend their own cultivars. This may or may not be adequate, since turfgrass species and cultivars differ in their performance characteristics.

A more objective approach in selecting a turfgrass cultivar is to consult the results from the National Turfgrass Evaluation Program (NTEP). The NTEP was established in 1980 to coordinate the evaluation of turfgrass species across the United States and Canada and is a sponsored program of the U.S. Department of Agriculture (USDA) and the National Turfgrass Federation, Inc. Since its inception, the NTEP has collected information on over 50 turfgrass characteristics from over 1000 different turfgrasses. This information is updated and released annually. The closest NTEP sites to Connecticut are located at the University of Massachusetts, University of Rhode Island, Cornell...
University, University of Maine and the Pennsylvania State University. The information from all NTEP sites is available to the public.

The preferred method to obtain the NTEP information is off the internet from the organization’s website located at the URL: http://www.ntep.org

They can also be reached at the following address:

National Turfgrass Evaluation Program
10300 Baltimore Ave. Bldg. 001, Rm. 245
Beltsville Agricultural Research Center-West
Beltsville, Maryland 20705
Phone: (301) 504-5125

The information from the NTEP includes site conditions and turfgrass management practices at the participating sites, listing of cultivars tested, listing of seed sources and seed companies, and ratings of turfgrass performance including overall quality, color, disease and insect resistance, density, and tolerance to cold, heat, drought and traffic. Information in the reports is presented in tabular form for each variable evaluated. The data are best utilized by choosing evaluation sites closest to your location, then comparing varietal performance for those sites. A full explanation of how to use the data is provided in each report. The NTEP program should provide a more objective approach in selecting turfgrass cultivars.

High quality turf begins with the proper turfgrasses adapted to conditions present at any one particular site. With a little planning and observation, it is possible to establish and maintain the turf quality at a particular site for many years with the proper selection of an adapted turfgrass followed by the proper management for that turfgrass.

REFERENCES


Michigan State University. Turfgrass Information Center. www.lib.msu.edu/tgif/


Seedland.com. www.sodding.com


Chapter 5: Lawn Establishment

Dana Karpowich, Edmond L. Marrotte and Timothy M. Abbey

The first line of defense against any turfgrass pest is a healthy plant, not chemical insecticides or even biological control. Proper turfgrass selection and establishment, followed by sound cultural practices such as fertilization, irrigation and mowing, enable the lawn to maximize growth and defend itself against common pests. The following chapters on turf establishment and turf maintenance explain in detail how to provide your lawn with a healthy growing environment.

Before developing a landscape, evaluate the site to decide where the grass, ground covers, shrubs and trees are to be located. Determine specifics such as sun versus shade areas, slopes and rocky areas. Proper plant selection and location is the cornerstone for building an attractive landscape with the least amount of pest problems. Though corrections can be made later, now is the easiest time to make decisions.

Turfgrass grows in a wide variety of soil types, but a fine-sandy loam or sandy loam, 6 to 12 inches deep is preferred. When this is not possible, a 4-inch base of soil is adequate as long as other conditions for growth are not limiting. Anything less than a 4-inch base may be acceptable but may not produce the desired quality of turfgrass. The majority of soils in Connecticut are categorized as fine, sandy loams. Soils much different in texture may result in greater challenges for establishment.

If additional soil is required at the site, either amend the soil or import topsoil from another source. The soil at the site can be amended with composted leaf mulch and other composted materials to add organic matter. This may not produce a 4- to 12-inch base, but will improve soil characteristics especially on sandy soils. Working with the parent material at a site, rather than importing topsoil from another source, has its benefits. This method helps to reduce the introduction of weed seeds that may not be found at the site. Topsoil is also expensive and its exploitation causes the disturbance of land elsewhere.

The introduction of additional topsoil from another source can be spread on the surface and incorporated to the depths discussed above. The deeper the soil layer desired, the more topsoil and expense are required. When buying topsoil, it is best to make an attempt to inspect the soil prior to purchase. Also, request screened topsoil to minimize the import of unwanted stones. Keep in mind that the term “topsoil” is any material that is on the soil surface. There is no legal definition of “topsoil.” In many cases, the soil brought in, usually at great expense, is not any better than the soil already on the site. If purchasing a significant quantity of topsoil, have the soil tested. The topsoil from another site can often be different in structure, texture and nutritional composition.

SOIL PREPARATION AND DRAINAGE

The lawn area should be cleared of all construction and unearthed debris such as stumps, branches, lumber, shingles, dry wall and stones larger than one inch in diameter. Poor soil preparation contributes to future problems such as soil compaction, dry spots and/or depressions. Soil samples should be taken to determine the nutrient levels for the new turf area (photo 5-1).

The initial grading should be conducted on the subgrade. This means removal of the top soil. The rough grade tries to minimize steep slopes or depressions that make turf care more difficult after turf establishment. During this period, grading must be designed to prevent surface water from collecting in low spots. Also, the grade must also be sloped to keep water from gathering around the foundation of the house, where it can move into the basement.

Most turfgrasses do not tolerate poor soil drainage. If the site is wet, an underground tile system may be necessary to drain excess soil moisture. Contact a qualified individual for help in designing a drainage system. This is an expensive procedure and should be done by a professional. Poor design can lead to many serious home and landscape problems.

A properly designed landscape should take into account surface drainage. As stated, the primary focus is on proper contouring which provides adequate surface drainage through the use of grassed waterways, ditches, French drains or mounds to divert water, or utilizes dry wells to drain small, wet areas. Drain tiles, consisting of clay, concrete or plastic, are placed 18 to 36 inches deep and 15 to 60 feet apart. The tiles should be placed in a herringbone or gridiron pattern. After all drainage issues have been addressed, the topsoil that was removed should be placed uniformly over the contoured area.
After the initial grade, apply the recommended amounts of limestone and fertilizer so they can be worked into the soil. The results from the soil test determine the amount of limestone and fertilizer required for optimum plant nutrient levels. These materials should be incorporated into the upper 4 to 6 inches of soil by tilling or harrowing (photo 5-2). Apply starter fertilizer at 1 lb N/1000 ft² if necessary. A starter fertilizer is a fertilizer in which the phosphorous content (the middle number on the bag) is twice the number of the nitrogen and potassium listed. A 10-20-10 grade of fertilizer is a typical example of a starter fertilizer. Phosphorous is essential in the establishment of many plants including turfgrass. Once the turfgrass seed has germinated and the turfgrass has become established, there is minimal benefit to the addition of phosphorous. Therefore, once the turfgrass is established, follow a fertilization program as outlined on the soil test report typical for an established lawn to maintain good plant growth. Incorporating the fertilizer and/or lime prior to establishment produces the optimum nutrient supply for turfgrass seedling growth. Once a permanent cover is established on the surface, the initial opportunity to incorporate materials into the soil has been lost.

After the amendments have been tilled, conduct a finish, or final, grade (photo 5-3). This step is important because it influences the overall appearance of the lawn. Use a hand rake to remove stones or other debris. Once the debris is removed, a light rolling can be done to firm up the soil for planting.

**SEED**

The turfgrass seed industry continues to improve the cultivars of all the primary turfgrasses – Kentucky bluegrass, fine-leaved fescue, perennial ryegrass and turf-type tall fescue. The seed purchased should include improved, named cultivars of certified seed (fig. 5-1). If the seed label does not include named cultivars, it is an indication of common types of turfgrass and may produce a substandard turf.

**When to Seed**

The preferred time for seeding cool-season turfgrasses is August 15 to October 1. During this time, the air temperature is cooler and the soil temperature is still warm. These 2 environmental conditions favor root growth and development of turfgrass. In addition, late summer precipitation becomes more dependable at this time to help keep the soil moist. Moist soil is essential for germination. Also, during late summer, grass seeds germinate with little competition from annual spring or early sum-
Grass seed can be sown by hand, with a broadcast spreader, or applied through a slice seeder. Follow the seeding rate recommendations from the seed label. Once seeds have been spread, lightly rake the area to cover grass seeds with 1/8 inch of soil. The biggest mistake made when seeding turfgrass is to cover the seed too deeply.

An optional step after seeding is to gently roll the seedbed to insure good soil to seed contact. The roller should not be excessively heavy. The seedbed can also be lightly mulched after the seeds have been sown. Mulch aids in holding the seed and soil in place, especially on sloping terrains. Mulch also helps to maintain soil moisture in the germinating seedbed. Adequate moisture during the germination process is necessary for establishment. Because mulches help maintain soil moisture, they are especially useful during late spring seeding when environmental conditions are limiting.

Sources of mulch include salt hay, straw, coarse burlap, recycled paper pellets (PennMulch) or synthetic mulching blankets (photo 5-4, 5-5). The use of farm hay is not recommended as a mulch source. Hay is generally full of weed seeds and further introduction of weed contaminants negatively affects the new seeding.

**WATERING**

Irrigation is the most important cultural practice for successful turfgrass establishment. Moisture is required for seed germination. The seedbed must be watered once the grass seeds have been sown or they will die (photo 5-6). Once the seedbed has been watered and moistened, it must remain moist in order for the seeds to germinate. If the seedbed is not mulched, a few light waterings a day may be required, particularly if it is windy and/or hot. The upper 1/2 inch of soil should remain moist during establishment. However, excessive irrigation, especially on warm, humid nights, increases the chance of disease outbreak on the turfgrass seedlings. Pythium is lethal to seedlings under these conditions. As you will see in chapter 6, watering recommendations for a newly established lawn are the opposite of a mature, previously existing lawn. The focus on an older

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*5-4: Straw hay on a seedbed.*

*5-5: PennMulch.*

*5-6: Non-irrigated seedlings.*
lawn is for infrequent and deep irrigation.

**MOWING**

Mowing a newly established lawn correctly is key in the development of a dense turfgrass stand. Newly-established lawns should be mowed at a height of 1 1/2 inches for the first 3 cuttings or until well established, which is generally through the fall. For example, as soon as the vegetation reaches a height of approximately 1 3/4 to 2 inches, mow off approximately 1/4 to 3/8 inch of the leaf blade. This is equivalent to 1/3 of the leaf blade area. The mower blades used to cut seedlings should be as sharp as possible so that the fragile seedlings are not uprooted. After mowing the lawn at 1 1/2 inches until well established, raise the height of cut to 2 inches. Once established, maintain the mowing height at 2 inches in spring and fall, and at 3 inches in summer.

It is a misconception to quadrant off and not mow the areas of newly established lawn. The fear of running a mower across the surface and damaging the new grass plants is not true. In fact, it produces quite the opposite effect. Young turfgrass plants, which are allowed to grow long and lanky, produce areas of thin, weak turfgrass. A thin lawn is unattractive and susceptible to weed encroachment. Therefore, this strategy of mowing at 1 1/2 inches during the early establishment phase of the lawn reduces the competition from weeds and stimulates tillering of the turfgrass plants. Short mowing heights for at least the first 3 cuts also enhances tillering of turfgrass, which leads to compact, dense plants. Thus, the greater the density of turfgrass, the less competition there is from annual grasses and broadleaf weeds. In addition, a dense turfgrass is more functional and attractive for recreation and other uses. (For more information, see the mowing recommendations for an existing lawn in chapter 6 on page 48.)

Established lawns that have been damaged by pests and/or environmental factors can be renovated following the same steps for establishment (photos 5-7 and 5-8).

**SODDING**

Laying down sod gives a landscape an instant lawn. This is the only shortcut for new lawn establishment. Soil preparation, lime and fertilizer application are as important with sod as they are with seeding. To ensure the highest quality, only use certified sod. Since the cost of sod is much higher than seed, it does not make sense to give insufficient attention to site preparation. A sod lawn may be installed at any time during the growing season provided water is not limited. Sodding should be avoided in July and August if irrigation is not possible. Sod establishment requires careful watering during the first few weeks. If the site does not have the irrigation capacity to maintain adequate soil moisture, seeding is wiser, since a sod failure is more costly.

Sod should be placed over moist soil. Connect the edges tightly, slightly tucking the edges to hide the seams while staggering the joints as if laying bricks. As soon as possible, lightly roll the sod and apply water. Water daily for several days, increasing the interval between waterings through the first few weeks as the sod roots to the soil. The sod and soil must be kept moist. Loss of sod is often due to insufficient water. As in an established lawn, mowing should take place when the grass is approximate 2 1/2 inches high. Remove no more than 1/3 the growth at each cutting.

**REFERENCES**


SOD SELECTION AND INSTALLATION TIPS

When purchasing sod, you should know what questions to ask the seller to determine whether the sod is right for your needs. Here is a list of questions to get you started and an explanation of why each is important.

What cultivar or cultivars are in the sod?
With numerous turfgrass cultivars, you must know if the cultivars in the sod perform well in your area. Most land grant universities take part in the National Turfgrass Evaluation Program (NTEP) and make recommendations for specific cultivars from those trials. Purchase only cultivars that your land grant university recommends or that others can document as having performed well in your region. See chapter 4, "Turfgrass Species Adapted to Connecticut" on page 29, for more information.

Are the cultivars in the sod from certified seed or sprigs?
Certification ensures genetic purity. It provides you with assurance that the product you are purchasing contains the cultivars indicated. High quality sod growers willingly provide copies of the certification labels or documents upon request.

Is the sod certified?
Some states have sod certification programs that ensure genetic purity and certain levels of quality. Sod certification programs are particularly valuable when you are drawing up specifications for bidding or in situations where your customer is relatively uninformed and wants to be sure a high quality product is used.

If the sod is a mixture of turfgrasses, what is the ratio of each species?
Kentucky bluegrass is sometimes added as a major component to a mix of creeping red fescue and perennial ryegrass, and sometimes, it is mixed in small amounts with tall fescue. In these situations, it is important to know the ratio of the planted mixture. For instance, the normal ratio (on a weight basis) for tall fescue sod is 80% to 90% tall fescue and 10% to 20% Kentucky bluegrass. These ratios perform well, and by harvest time the sod is predominately tall fescue. However, if the mixture contains high percentages of Kentucky bluegrass, the sod is prone to what is called “pie-plating.” In other words, pie-plate size clumps of tall fescue develop as the sod matures. You cannot set up a meaningful management program without knowing the ratio of the planted mixture.

What is the actual grass content of the sod?
Although planted as 90% tall fescue on a weight basis, tall fescue/Kentucky bluegrass mixtures are almost 1 to 1 on a seed count basis. Tall fescue seed is larger than Kentucky bluegrass seed, so it has fewer seeds per pound. Tall fescue requires a much warmer soil to germinate than Kentucky bluegrass. Thus, a 90/10 mixture planted in late spring or early summer, when soils are warmer, tends to contain significantly greater tall fescue than the same mixtures planted in fall or early spring when soil is cool. If you want tall fescue sod and you purchase sod having a high Kentucky bluegrass content, it may not perform as you expect.

How old is the sod?
Old sod is not necessarily bad sod. However, older sods of Kentucky bluegrass can have excess thatch. With excessive thatch, turfgrass crowns are elevated in the thatch, and the turf is predisposed to drought stress. If you purchase sod with excessive thatch, it may be slower to root. Thus, you need to include extensive core aerification in the maintenance program to help decompose the thatch.

Does the sod have netting?
Some sod is grown with netting to increase sod strength and shorten production time. The netting can be troublesome in certain situations where shoes can catch. In most situations, it causes no problem. Be aware that when produced with netting, tall fescue sod is sometimes grown as a monostand. Thus, it is not the best choice for a heavily trafficked area. These areas require sod that includes some Kentucky bluegrass for lateral healing.

At what depth is the sod cut?
Sod is normally cut with 3/4 inch (plus or minus 1/4 inch) of soil attached. Sod producers do not want to send any more soil with the sod than is necessary to ship a high quality product. They may vary the thickness of the cut daily, basing thickness on the age and quality of the sod, soil moisture and other considerations. Knowing the cutting depth helps you determine irrigation frequency and how fast the sod will root. Thick sod takes more time to root, but does not need water as frequently as thin sod.

On what type of soil is the sod grown?
If the soil types of the growing field and the landscape are quite different, layering develops at the interface between the sod and the landscape soil. This, in turn, leads to

rooting problems. Restricted rooting has been noticed when laying sod with a fine-textured or an organic soil over sandy soil. Most problems occur when heavier soils are placed over lighter, sandy soils. It is best to purchase sod grown on soil that is reasonably close to the soil texture at the installation site. If significant textural differences exist between the sod soil and the installation site soil, you would be wise to aerify several times after sodding and during the establishment phase, dragging the cores to minimize the impact of layering on rooting.

What is the lag time between harvest and delivery?
Long delays between harvest and delivery waste stored food reserves in the grass plants because they continue to respire while rolled on the pallet. Delay is particularly harmful during hot weather when respiration rates are at a maximum. In addition, if the grower mows sod high, returns the chippings, uses high nitrogen levels or cuts the sod thin, the sod heats faster on the pallet. The best situation is to install the sod within 8 hours of harvest. Going longer than that leaves the sod with fewer stored food reserves and, thus, less potential to immediately develop an aggressive root system. Plus, the sod is more susceptible to disease attack.

What was the mowing height at the sod farm?
You need to know what mowing height the sod producer used so you can continue mowing at the same height. A lower mowing height after installation is not advised because this is a time when the grass actually needs maximum photosynthetic potential to replace the stored food reserves it lost in the shock of harvest and transport. Slightly higher mowing heights after installation help promote rooting. Once established, cut the grass at the appropriate height for the species.

Is the sod rolled or folded on the pallet?
It is easier to hand-carry rolled sod than folded sod without tearing. If you must handle the sod extensively at the installation site, you may prefer rolled sod.

Has the sod been treated with a preemergence herbicide?
If you are receiving sod in the spring, you need to know whether to treat for crabgrass. If the sod grower has already applied an herbicide, applying another preemergent at the installation site could harm root development. If the sod producer has not treated the sod, you may need to apply one, especially if the area has the potential for crabgrass invasion between sod pieces. When applied at the time of installation, some preemergent herbicides tend to inhibit new root development in sod. Consequently, some pre-emergent herbicides are not recommended for use on newly installed sod. Always check preemergence herbicide labels before applying. Using a postemergence herbicide to control breakthroughs may be the best approach.

Has the sod been treated with a growth regulator?
Some sod growers are using growth regulators to reduce mowing and increase sod rooting potential. You need to know how long it has been since the producer applied the material, what it was, and the application rate. Knowing this gives you an idea of how much residual effect is still possible and assists you in setting up a reasonable mowing schedule.

When was the sod last fertilized?
It is particularly important to know when the grower made the last nitrogen application, how much was applied and the nitrogen source. For example, you do not want to fertilize at installation if the cool-season sod you are installing in the spring was already fertilized with one pound of soluble nitrogen. That would be too much nitrogen.

Has the sod received an iron or biostimulant application in the last 30 days?
Researchers have demonstrated substantial root and shoot stimulation and significant increases in sod shear strength after spraying Kentucky bluegrass with seaweed-extracted cytokinins, iron and cytokinin-like fungicides, such as triadimefon (Bayleton) and propiconazole (Banner). Four weeks after harvest, seaweed extract, triadimefon and propiconazole have increased sod rooting by 88%, 117% and 89%, respectively. If the sod grower has already applied these materials, you do not need to repeat the application. But if the producer has not used these materials, you may want to apply them to aid rooting.

What pesticides have been applied in the last 30 days?
Some systemic fungicides control common turfgrass diseases for up to 28 days. Some insecticides also have extended residual control. Therefore, reapplying these materials is a waste of money. Also, the grower may have already treated for broadleaf weeds in the sod, and additional treatment could be detrimental. Some sod growers are using isoxaben, which provides significant residual broadleaf weed control and could impact your post-establishment broadleaf herbicide program.

Be a prudent sod buyer. The above questions are particularly important to address if you want to maximize your chances for establishment success and long-term turfgrass quality.
Chapter 6: Lawn Maintenance

Dana Karpowich, Edmond L. Marrotte and Timothy M. Abbey

Maintenance of an established, healthy lawn through several growing seasons with minimal disease, insect or weed problems is demanding. The lawn requires continual attention and care. Good lawn maintenance should integrate several basic practices. If one practice is neglected, the lawn may decline.

IRRIGATION

Watering is done to supply the necessary moisture for turfgrass growth (photo 6-1). Watering practices, such as the amount, frequency, duration, timing, pattern and intensity, impact aspects of overall turfgrass growth. Typically, the average Connecticut lawn requires 1 to 1 1/2 inches of water per week during the growing season. Natural precipitation and consideration of soil type also influence the total amount of irrigation needed.

A helpful hint to determine if turfgrass needs to be watered is the slow recovery from some form of traffic, such as footprints or tire tracks. This is a good indication that irrigation needs to be applied. Also, at this time, the turf has a purplish or dark blue color, not the typical green color.

The irrigation application must be done on an infrequent basis (just prior to drought stress symptoms) and deeply (long enough to soak down to at least a 3-inch depth) to provide the greatest benefit to the turf. Growing conditions, soil type and monitoring help determine when and for how long to water the lawn. Sandy soils do not retain water as well as finer-textured soils because water drains quickly through large pore spaces in sand. A sandy textured soil may require irrigation more frequently but for shorter periods of time. In finer-textured soils, water infiltration may be slower but water is retained longer and irrigation applications can be spaced at longer intervals. This strategy of infrequent and deep irrigation allows for the development of deep roots that can find moisture away from the surface. Avoid frequent watering practices that do not encourage the development of deep roots. Shallow rooted turfgrass is more susceptible to dry conditions. Thus, a prolonged break in this type of irrigation routine places the area under stress.

The intensity of the irrigation application is also very important. The water application rate should not exceed the infiltration rate of the soil. A gentle, steady intensity of irrigation supplies the most benefit for turfgrass growth. This can minimize the potential for surface runoff, and reduce the risk of pesticides and fertilizers moving off-target. Sloping surfaces or thick thatch areas can reduce or impede water infiltration. Runoff from a fast-tracking rain-storm that delivers over 1 to 2 inches of rain per hour, most of which will not infiltrate the turfgrass surface, provides little benefit to the plant and its root system.

The timing of an irrigation application is best done in early morning when the dew is still visible on the grass plant. Water turfgrass beginning after sunrise between 5:00 AM to 8:00 AM. This allows grass blades time to dry before night. Stop applying water once the dew has dried to avoid extending the time the grass is normally wet from dew, and increase the incidence of some lawn diseases. The second best time to apply irrigation is in the late evening/early morning after the dew has fallen. Avoid watering in late afternoon and early evening, particularly during hot, humid weather. Irrigating during hot, humid afternoons and evenings also promotes the outbreak of fungal diseases. Mid- to late afternoon irrigation also increases the amount of water lost to evaporation.

The pattern of irrigation should be uniform. Check the irrigation pattern by setting up rain gauges or empty tuna fish cans around the area of irrigation. Run the irrigation and check all reservoirs to see if the water is being distributed evenly. Water must penetrate to the depth of the root system throughout the entire lawn. Usually, one inch of water is sufficient to reach the desired soil penetration.
In the case where on-demand irrigation is not available and homeowners have to practice water conservation, alternative solutions are required. There are physical and economic limitations to irrigating lawns. There is also an obligation to protect and conserve water quality and supply by not using it for watering lawns. If irrigation cannot be applied, two things must be considered. First, this situation demonstrates the importance of proper turfgrass selection at the time of establishment and renovation. Drought-tolerant turfgrass, such as the turf-type tall fescues, should be used so that the effects of any drought stress are minimized.

Second, in summer, many homeowners choose not to irrigate the lawn. They conserve the water for economic or environmental reasons, or they use their precious water supply for vegetable gardens while living with the brown-colored lawn. A brown or dormant lawn occurs when water is limiting turfgrass growth. Cool-season turfgrasses naturally enter a stage of dormancy as a survival mechanism to drought. The lawn regains its green color in the fall when temperatures cool and precipitation increases. However, there is always the possibility that some patchy areas remain brown, as the rest of the turf turns green. This can be attributed to severe drought stress that has killed the turf outright or damage from insect feeding or disease. If the environmental conditions become excessively hot and dry, 1/4 to 1/2 inch of water should be applied every 2 to 4 weeks. This ensures that the grass can grow once conditions improve.

**Mowing**

Mowing practices influence other cultural operations including watering and fertilization. The turfgrass species, vegetative characteristics of the turfgrass, plant vigor and the intended use of the turf area often dictate mowing. The height, frequency and pattern of cut directly influence turfgrass quality.

**Mowing Height**

Most lawns in Connecticut consist of more than one turfgrass species. Each species has an ideal height of cut for optimum performance. Typically, these species are intermixed throughout the lawn, and it is not practical to select a height of cut to cater to only one species with disregard for the rest. Therefore, recommended mowing heights coinciding with seasonal times of the year provide more than satisfactory results. In general, the mowing height recommended for home lawns is 1 to 2 inches in spring and fall, and 2 1/2 to 3 inches during warm summer months. To measure the height of cut, simply take a ruler and measure from the base of the plant to the tip of the leaves. The closer the turfgrass is mowed, the greater the cultural requirements and expertise to maintain it. Closely mowed turfgrass is more susceptible to drought, disease, weed invasion and other problems.

A deep root system is more tolerant of heat and drought stress. In early spring (April), mow turf at the 1- to 2-inch height. Then gradually raise the height of cut up to 3 inches from late spring into early summer to insure deep rooting of the turfgrass. The higher the plant is allowed to grow in late spring, the deeper the root system develops. With a deep root system, the plant can reach a greater reserve of soil moisture and nutrients. A strong and healthy root system is particularly important during summer months when moisture may be deficient. Grass that is allowed to reach a reasonable height tolerates stress conditions better than a lawn that is cut shorter than 1 1/2 inches. Finally, cut the turf at the higher setting (2 1/2 to 3 inches) during stress periods (June, July and August) to reduce the temperature at the soil surface and around the crown of the plant, which helps reduce overall plant stress.

Another factor that can affect mowing height is thatch (explained in detail on page 83). The mower tends to sink into the thatch, thereby lowering the intended height of cut, causing the mower to "scalp" the turf. Scalping is the removal of an excessive amount of grass leaves (more than 1/3) at any one cutting, giving the lawn a brown, stubby appearance (photo 6-2). Continuous scalping ultimately results in an overall thinning of the turfgrass stand and a less attractive lawn. Thin turfgrass and bare spots as a result of scalping are prone to weed invasion. Additionally, scalping is accentuated or enhanced by high nitrogen fertilization levels. To reduce the incidence of scalping and/or reduce the number of cuttings per week (especially in spring), reduce or eliminate early to mid-spring applications of high nitrogen fertilizers. Turfgrass blade growth is greatest in spring, and nitrogen fertilizer applications only cause increased mowing requirements.

A vigorous and actively growing lawn that is not scalped continuously and is cut at the correct height can actually provide some natural weed control through effective competition against weeds, particularly annual weeds. Most common lawn weeds do not grow well in shade, and the shade from a dense turf is often sufficient to inhibit the germination of weed seeds.
Frequency

The frequency of cut should be often enough not to remove more than 1/3 of the total leaf blade during each mowing. To achieve the 1/3 removal, mow frequently when conditions are favorable for turfgrass growth. In spring and fall, mow 2 to 3 times per week, and in summer mow once a week or as needed. Thus, if the desired mowing height is 2 inches, the lawn should be mowed when it is 3 inches high to ideally maintain the removal of only 1/3 of the leaf blade per mowing. Removal of more than 1/3 of the leaf blade causes scalping.

Mow selectively around dormant areas of turfgrass. Unirrigated cool-season grasses become dormant during warm periods as a defense mechanism for survival. These areas are straw colored and with no active growth. The lawn mower can cause mechanical injury to the crown of the grass plant during dormancy. The crown is the bud of the grass plant where the plant leaves originate. Injuring or killing the bud results in the death of the plant. Mechanical injury produces irregular areas of brown turfgrass that may require overseeding in the fall.

Continue to mow the lawn until seasonal growth stops. Long, lush fall growth can mat down and encourage the development of snow mold diseases. Late summer fertilization and mild fall weather in Connecticut can encourage turfgrass growth into November and December, particularly along coastal areas. In spring, begin mowing at 1 1/2 to 2 inches and gradually raise the height of cut to 2 1/2 to 3 inches by summer. As cooler temperatures prevail, gradually lower the height of cut back to 1 1/2 to 2 inches.

Clipping Management

The rule of thumb is to leave the grass clippings on the lawn after each cutting. Over 40 years ago at the birth of the first subdivision in Levitt Town, Long Island, people started picking up lawn clippings because they saw their neighbor or gardener doing it. Since that time, people believe the recommended procedure for mowing is to bag and remove grass clippings. However, there is no benefit to removing lawn clippings. Clipping removal involves the use of labor either from noisy blowers or mowers, which burn fossil fuel, or time spent raking. Clipping removal creates another nemesis of what to do with the clippings. Since legislation has been passed in Connecticut, clippings are no longer permitted at recycling and transfer stations. Lawn clippings do not contribute to the development of thatch. In fact, clippings recycle plant nutrients at the equivalent of at least one fertilizer application during the growing season. Also, returned clippings have been shown to decrease the incidence of certain diseases and increase earthworm populations. Grass clippings are comprised of over 90% water. When following the 1/3 rule, lawn clippings easily dry up and are unnoticeable within a few days.

Lawn clippings may present a problem if the grass is allowed to grow too long, and thick clumps of clippings are left behind (photo 6-3). If it is not possible to see the underlying grass once the clippings are dried, remove them immediately. Excessive clumps of clippings smother turfgrass causing death and bare spots. Mow when the grass is dry. Mowing wet turfgrass makes grass clippings clump together and accumulate, which blocks sunlight from turfgrass. Mowing wet turfgrass easily spreads disease too.

Pattern and Cut

The mowing pattern should be varied with each mowing to encourage vertical growth of the grass shoots. Varying the direction with each mowing increases wear tolerance and minimizes soil compaction from repeatedly traveling over the same places with the lawn mower.

For the best possible cut, maintain a sharp mower blade (photo 6-4). A dull mower blade causes the tip of the leaves to fray and turn brown giving the lawn an unsightly appearance. The tips may also become stunted as a result of cutting with a dull lawn mower blade. This can occur with all turf grasses but is most pronounced on perennial ryegrass. A sharp mower blade improves the overall appearance of the lawn, helps minimize water loss and may reduce the ability of pathogens to enter the host. Mower blades can be sharpened as often as daily for the commercial mowing service. Homeowners are encouraged to sharpen the mower blade every third or fourth mowing, or as often as possible depending on the intensity of use. To sharpen a rotary mower blade, disconnect the spark plug and remove the mower blade from the bottom of the mower deck. Sharpen the blade with a file or take it to a hardware or garden center store that specializes in this service. It is not necessary to take the entire lawn mower.

Types of Mowers

There are 2 different types of mowers used to cut managed turfgrass. This includes the rotary and the reel mower. The rotary mower is the most versatile and commonly used type of mower for home lawns (photo 6-5). It can be used to mow tall and thick-stemmed grass and weeds, and
A rotary mower cuts the top of the grass plant off by the impact of the mower blade in a horizontal plane. For this reason, it is important to maintain a sharp mower blade because a dull blade will tug and rip the top of the grass blades rather than cut them (photo 6-6). Rotary mowers can have a conventional single blade or a double-type (mulching mower) blade. Mulching mowers can cut grass blades small enough so that they fall back through the foliage canopy to the soil. Mulching mowers are not recommended for cutting high turfgrass because excessive clippings clog up the mower. For this reason, a conventional rotary mower achieves the same results as a mulching mower when frequent and proper mowing is observed.

A **reel mower** produces the highest possible mowing quality when properly maintained and operated (photo 6-7). They perform best on relatively smooth surfaces and are preferred under conditions of close cutting and where a dense turf is to be maintained. Reel mowers should be used on turfgrass maintained at 1 1/2 inches or lower. Since most home lawns are maintained at 2 to 3 inches and are generally not mowed frequently enough, this type of mower is not practical for home lawn application. For this reason, only professionals on high quality turf such as golf courses, athletic fields and sod farms generally use them.

A reel mower consists of a rotating reel cylinder with blades and a stationary bedknife. The cutting action of the reel against the bedknife results in a scissor-type effect rather than the impact action of the rotary mower. The sharpness of the cutting edges and proper adjustment of the bedknife against the reel blades influences the mowing quality. Dull cutting surfaces or an improperly adjusted bedknife tear the grass blade rather than cutting it, or the blades are pinched (photo 6-8). The damaged and bruised leaves turn gray, then brown at the tip and growth may become stunted as
6-8: Injury to turfgrass from dull reel mower blades (pinching effect).

As a result, thus, reel mowers require high maintenance in terms of daily blade sharpening and adjustments. Also, reel mowers do not work well in high grass and on tough seed stalks and weeds. Therefore, due to the high maintenance requirements and mowing limitations, reel mowers are generally not utilized on home lawns by homeowners.

**IPM Suggestions for Reducing Mowing Requirements for Home Lawns**

Reducing the amount of time spent to mow and maintain the home lawn can be achieved through the use of some simple cultural management techniques. First, plant and overseed the lawn with recommended grass species that are maintained at higher heights of cut. The utilization of fine leaf fescues such as Chewings, hard and creeping red fescue, can reduce the number of times per week required for mowing. (For more information on grass species see chapter 4 on page 29.)

Reduce or eliminate fertilizer applications. Turfgrass grows most vigorously in the spring. Spring fertilization without a doubt increases turfgrass growth and increase mowing requirements. Therefore, eliminate or reduce the fertilizer applications in March and April. This reduces the mowing requirements for home lawn management. Turfgrass plants benefit the most from fertilizer applied in late August or early September, not in spring. Avoid high nitrogen fertilization during the hot and dry summer months. The nitrogen either volatilizes, if not watered in and taken up by the plant, or the application causes excessive growth which makes the turf more prone to disease problems.

Remember that some degree of compromise is needed when deciding how green the lawn has to be versus how many times per week the lawn needs to be cut. Many lawn care services only have the time to mow individual properties once a week. For this reason, the need to reduce or eliminate spring fertilization may already be decided for you, based on the frequency of cut in spring.

**COMPACTED SOIL AND AERIFICATION**

One of the most serious problems that can cause turfgrass decline is soil compaction, the pressing together of soil particles into a more dense soil mass. Soil compaction is usually found in the top 2 to 3 inches of soil. However, soil compaction can occur at greater depths when initial grading during home construction is improperly done using heavy equipment. Once the turf is established, the soil can become compacted from excessive activity, such as use of a walking path.

Compacted soil has a high bulk density (photo 6-9) or more simply stated, is denser than soils with less compaction, which have more open, large-pore spaces. As a result, compacted soil heats up more quickly allowing greater soil temperature extremes to occur. This makes turfgrass more prone to drought and heat stress while overall turfgrass growth is less vigorous (photo 6-10). Soil water infiltration and percolation are reduced and the amount of surface runoff is increased. Surface runoff from an IPM perspective can be an important source of pesticide and fertilizer movement from lawns, to off-target locations.

6-9: Closeup of soil profile. There is no core space due to compaction.

6-10: Dead turf from soil compaction.
areas such as storm drains, streams, ponds, lakes, rivers and the Long Island Sound.

Soil compaction reduces soil aeration and oxygen levels necessary for root development and growth. Compacted, low-oxygenated soils restrict root growth to the point where the root system may eventually die. Compacted soil with low porosity can also mechanically impede root penetration through the soil. Soil compaction is often the cause of many underlying problems related to the poor appearance of a thinning lawn. It can be difficult to diagnose from an individual sample without an on-site assessment from an experienced turfgrass professional.

**Soil Compaction Management**

Established lawns with compacted soil can be managed by core aerification or coring. Core aerification involves the use of a machine with a series of hollow or spoon-type tines that remove soil cores and leave holes in the turf (photo 6-11). The action of the spoon tine is designed to move in an arc under the turf that results in a loosening action in addition to the removal of the soil cores. Coring helps to increase oxygen levels and increases the porosity of the soil. As the machine removes the turf and soil plugs, they are deposited on top of the lawn (photo 6-12). The plugs are 0.25 to 0.75 inches in diameter and can range from 1 to 3 inches in length. The machine spaces cores between 2 to 6 inches apart. For the best results, there should be a core hole every 2 inches in the turf surface. Soils in Connecticut have an abundance of stones that can limit the depth of the aerator or cause damage to the aerator tines.

Soil cores pulled out of the turf should be left on the lawn surface (photo 6-13). Soil cores are generally moist and break apart within a few days. A drag, mat or hand rake can also be used to help break up soil cores. Coring can be done almost anytime of year, but is best done when there is adequate soil moisture. The best time of the year to aerify is when the turf is growing vigorously. For cool-season turfgrasses, spring or late summer are appropriate. The soil should be moist, not dry, so that the cores stay intact and thus come out of the holes. When soil compaction is severe, coring may initially be needed more than once during a calendar year. Core aerification is an effective soil management tool that can be implemented annually to benefit the lawn. (For more information on core aerification including types of aerators, turn to the thatch management section of this manual on page 83.)

There are a number of benefits to core aerification:

- Assists with thatch management, especially where soil cores are reincorporated or where topdressing follows coring.
- Improved turfgrass response to fertilizers.

Though the benefits of aerification are substantial, there is the potential for a few disadvantages such as:

- Temporary disruption of the turf surface.
- Increased potential for turfgrass dessication as subsurface tissue is exposed.
- Increased weed development when conditions favor weed seed germination.

To reduce the adverse effects from aerification, the soil cores should be mechanically broken down or the turf area should be topdressed with a suitable soil.

One way to break up the cores is to do a shallow vertical mowing. The equipment cuts through the thatch and into the soil. This brings organic matter and soil to the surface. Vertical mowing should be conducted when the turf is dry and the soil is not excessively moist. If turf and soil are too wet, large chunks of turf are ripped. Not only does vertical mowing aerify the soil, it is a good method for reduction
of excessive thatch. However, it should be done when turf is actively growing, not in the summer during drought dormancy. If necessary, the excess organic debris that is deposited on the turf surface should be raked and removed.

**RENOVATION OF AN ESTABLISHED LAWN**

There are many instances where an established lawn has become damaged due to physical, environmental or pest problems. Under these circumstances, it is not necessary to remove and seed an entirely new lawn but rather execute a lawn renovation or overseeding. A lawn renovation is best done in late summer when traditional seeding is done. There are several methods used to renovate lawns.

The first example for renovation is thinning, compacted turfgrass areas with little or no thatch. This is usually found under shade, partial shade and/or heavy traffic conditions. Loosen the bare areas of soil as deeply as possible, and remove unwanted vegetation and debris. This can be done by hand with a hand, metal bow rake. This method is labor intensive, but it is less expensive compared to renting equipment. A rototiller can also be used to loosen the soil. A rototiller can easily loosen soil but may bring many stones and weed seeds to the surface. A rototiller does require some strength and skill to operate, as well as the cost for rental. Do not rototill saturated soil. Rototilling wet soil can actually cause soil compaction and should not be attempted under this condition.

Loosen the bare soil areas as deeply as possible. Rake up and remove unwanted plant debris and stones. Add limestone and fertilizer, according to soil test recommendations, and physically work them into the loosened soil surface. Finish the grading and sow the grass seeds by hand, or with a hand-held seeder or broadcast spreader. Lightly cover the seeds with about an 1/8 inch of soil either by raking with a leaf rake or sprinkling lightly with topsoil.

Once grass seeds have been sown, follow the starter recommendations for fertilizing, watering and mowing listed in the lawn establishment section on page 41.

Another effective method to loosen and prepare the soil surface for seeding is with a core aerifier. A core aerifier loosens the soil, creates small holes and prepares the soil for overseeding. Coreing is less labor intensive than hand raking, while helping to alleviate soil compaction. Remove unwanted vegetation and stones prior to aerating. Operate the core aerifier as many times over the lawn area to produce a hole every 2 inches in the soil surface. Apply fertilizer and limestone from soil test recommendations prior to aerification to facilitate their movement into the soil profile while coring. After coring, grass seeds can be sown by hand, hand-held seeder, broadcast spreader or slice seeder. Again, follow the starter recommendations for fertilizing, watering and mowing listed in the lawn establishment section.

A slice seeder can be used for lawn renovation. This machine has disks that vertically cut into the turf surface and make an opening or furrow. The slice seeder has an attached seed box where the grass seed is placed. Individual tubes extend down from the seed box to the vertical disks at the base of the machine. The slice seeder is operated across the turf surface as the disks penetrate the soil and seeds are dropped into the furrow. The depth of the slice seeder can be adjusted. The desired depth of seed placement is deep enough to pass through the thatch but not too deep to cause germination failure. The seeder should be run in 2 directions with the second direction being on a 70° angle to achieve proper coverage with seed. Follow the starter recommendations for fertilizing, watering and mowing listed in the lawn establishment section.

The slice seeder can be used on thin, damaged turf areas where there are no underlying conditions such as excessive thatch or soil compaction to limit turfgrass establishment and growth. This method of renovation reduces the amount of hand labor and raking associated with renovation. If an area is heavily compacted, core aerify prior to slice seeding. In cases where thatch accumulations are excessive, removal of the thatch with a sod cutter is recommended prior to seeding with a slice seeder or other seeding method. Slice seeders require some strength and skill to operate and transport. They can range from $100 to $250 to rent on a daily basis and may not be suited for use by everyone.

Renovation is also possible for areas with excessive thatch accumulations. The thatch must be physically removed prior to loosening the soil and overseeding. Thatch is a poor medium to seed directly into. Grass seeds may germinate in thatch, but quickly die because they do not have the ability to draw water directly from the soil. When thatch is less than 1/2 inch, a power rake or vertical mower can be used to remove the thatch. The grass seed must contact
the soil for germination and survival. Several passes will probably be necessary to remove a significant amount of thatch to insure good soil to seed contact. Once the thatch has been loosened, rake up the mixed thatch and soil debris and remove. Topsoil may need to be added to areas where thatch has been eliminated to level out the lawn surface. After grading and adding topsoil, sow the grass seeds. Then follow the starter recommendations for fertilizing, watering and mowing listed in the lawn establishment section.

A sod cutter can also be used to remove the thatch mat, if it is over one inch, prior to loosening the soil for grading. A sod cutter is a gas-powered machine with a knife blade that is positioned to cut under the thatch and remove the sod. Failure to remove excessive thatch prior to seeding results in failure of the renovation because seeds require direct contact with the soil for germination and survival. Once thatch has been cut off, loosen soil by hand or rototiller. Proceed with rough and final grading, along with the addition of topsoil or amended topsoil.

REFERENCES


Chapter 7: Turf Weeds and Their Management

Karl Guillard

The simplest definition of a weed is any plant that grows where it is not wanted. In turf, there are many undesirable plants that are considered weeds. Most are broadleaf and non-turftype grasses (such as crabgrass) or grass-like plants, but, depending on certain situations, turfgrasses themselves may be considered weeds. For example, creeping bentgrass is desirable on a golf course, but is often considered a weed in Kentucky bluegrass lawns; tall fescue is desirable along walkways and in low maintenance areas, but is a weed in fine-textured turf areas. Often, the objective and purpose of the turf area dictate which plant species are desirable and which are not. (Remember, as you read through the following turf pest chapters, maintaining detailed scouting records can provide valuable information that might help with future decision-making.)

In turf areas, weeds are undesirable because:

- They compete for moisture, light and nutrients.
- They disrupt turf uniformity and reduce turf quality by imparting different textures, producing flowers and seed heads, growing in patches or clumps, producing poor color, or dying under stress conditions leaving dead areas during different times of the year.
- Most are prolific seed producers with seeds that are long-lived presenting a weed control problem for many years; are fast to germinate under a wide range of environmental conditions; and produce seedlings with faster growth rates than turfgrass. They can often skip juvenile stages of growth (precociousness).
- Many spread vegetatively – rhizomes, stolons, tubers, bulbs, corms, fragments, creeping stems and creeping roots, which makes control difficult.
- They reduce functional quality – wear tolerance, recuperative potential.
- Some attract bees, produce injurious spines or thorns, are poisonous, or contain skin irritants.

Effective weed control programs in turf should be based on the following 4 components:

1. The ability to identify the weeds in question. This is an essential first step to good weed control because weeds do not respond the same to various weed control practices. For example, crabgrass is unaffected by most herbicides used for dandelions, and vice versa.

2. Understanding the weed life cycle. The best time to control a weed is based on the weed’s life cycle. In general, weed control is easier at the seed germination and seedling stage than at a more mature growth stage.

**WEED CLASSIFICATION**

For practical purposes, weeds are grouped or classified according to morphology and growth cycles:

**Weeds Classified by Morphology**

- *Grass and Grass-like*
  - monocots – true grasses, sedges, rushes, *Allium* spp. (wild garlic and onion); long narrow leaf blades with veins running parallel to each other; lack showy or colorful flowers, leaf shapes are similar among species
  - dicots – usually wider leaves than grasses; leaves typically have a main vein that divides the leaf in half with network of smaller veins forming a netlike pattern on each half; distinct leaf shapes and arrangements on stems; often have showy or colorful flowers

**Weeds Classified by Growth Habit**

- **Annuals**
  - complete life cycle in one season or less; large emphasis on seed production
  - *summer annuals* – germinate in the spring, set seed in the summer, die in the fall (e.g., crabgrass)
  - *winter annuals* – germinate in the late-spring or early fall, survive in a dormant state over the winter, set seed in the spring, die in the summer (e.g., common chickweed)

- **Biennials**
  - complete life cycle over 2 seasons; emphasis on seed production in the second season
  - *first season* is entirely vegetative growth – prostrate form is called a rosette
  - *second season* – produce flowering stalk in the spring, set seed in the summer, then die (e.g., wild carrot)

- **Perennials**
  - complete life cycle over many seasons
  - *Simple* – spread only by seed (e.g., dandelion)
  - *Creeping* – spreads by seed but mainly by vegetative organs such as rhizomes, stolons, tubers, bulbs, corms, fragments, creeping stems and creeping roots, which makes control difficult (e.g., yellow nutsedge); more emphasis on vegetative organs and less emphasis on seed production
3. Understanding turfgrass ecology – response of weeds and turf to the environment and cultural practices. Weed growth and development is affected by changes in weather, soil conditions and management practices imposed on the turf. For example, high fertility inputs, irrigation and low frequent mowing favor the growth of annual bluegrass. Hot, dry conditions favor crabgrass.

4. Understanding the various benefits and drawbacks of various control practices – preventive, cultural, mechanical, chemical and biological. A good IPM program includes aspects of various control practices and is not too dependent on one particular control method.

Weeds are opportunistic. Given the chance, they will thrive and become competitive. The best weed control method in turf is prevention. That is, create an environment that favors the desirable turfgrass more than weeds. Any cultural practice that increases the density and vigor of the desirable turfgrasses discourages competition and infestation of weeds. Weeds can only exist if there is space for them. When turfgrass density is high, weeds are normally minimal because of high competition from turfgrasses. The presence of a sizable weed population indicates that the turf is not dense enough and/or that the management program needs improvement, or the improper turfgrass species or cultivar is being used for the site conditions. When weeds become numerous enough to create problems, it is time to reevaluate current practices and correct any weaknesses.

Certain species of turfgrass or weeds can be used to indicate specific problems in a turfgrass area. Other weeds, such as dandelions, can grow under a number of environmental or cultural conditions (photos 7-1 and 7-2). The following information shows which weeds exist in the presence of adverse site conditions:

**Wet, Poorly-drained Soil**
- Algae
- Annual bluegrass (photos 7-3 and 7-4, fig. 7-1)
- Buttercups
- Docks (photo 7-5, fig. 7-2)
- Moss
- Nutsedge (photos 7-6 and 7-6a)
- Plantains (photos 7-7 and 7-8, figs. 7-3 and 7-4)
- Rushes
- Sedges
- Smartweeds (fig. 7-5)

**Droughty, Excessively Well-drained Soil**
- Birdfoot trefoil
- Black medic (photo 7-9, fig. 7-6)
- Cinquefoils (photos 7-10 and 7-10a, fig. 7-7)
- Crabgrass (photo 7-11)
- Goosegrass (fig. 7-8)
- Leafy spurge
- Quackgrass (fig. 7-9)
- Rabbit foot clover (fig. 7-10)
- Speedwells (fig. 7-11)

**Soil Compaction (low oxygen diffusion)**
- Annual bluegrass
- Broadleaf and Blackseed plantain
- Corn speedwell
- Goosegrass
- Moss
- Pineapple weed (fig. 7-25)
- Prostrate knotweed (photo 7-26, fig. 7-26)
- Prostrate spurge
- Slender rush

**Mowing Height Too Low**
- Annual bluegrass
- Chickweeds
- Common purslane (photo 7-27, fig. 7-27)
- Crabgrass (photos 7-28 and 7-29, figs. 7-28 and 7-29)
- Creeping bentgrass
- Ground ivy (photo 7-30)
- Moss
- Some speedwells

**Shade**
- Common chickweed
- Creeping speedwell
- Healall (photo 7-31)
- Moss
- Mouse-ear chickweed
- Violet (photo 7-32)
Keep in mind there are limitations to using the above list. Many weed species are adaptable to a wide range of soil and environmental conditions. Therefore, other diagnostic techniques, such as soil tests, should be used in conjunction with indicator plants. Do not use an individual plant or individual species to diagnose a problem turf area. Use as many plants or species as possible.

Continued on page 66.
7-5: Curly dock.

7-6 left: Nutsedge.

7-6a inset: Nutsedge roots showing runners and nutlets.

7-8 and Fig. 7-3: Buckhorn plantain.

Fig. 7-4: Broadleaf plantain.

7-7: Broadleaf plantain.
Fig. 7-5: Smartweed.

Fig. 7-6: Black medic.

Fig. 7-9: Black medic. Also pictured is clover.

7-10 and 7-10a inset: Cinquefoil.

Fig. 7-7: Cinquefoil.

7-11: Crabgrass.
Fig. 7-8: Goosegrass.

Fig. 7-9: Quackgrass.

Fig. 7-10: Rabbit foot clover.

Fig. 7-11: Common speedwell.

Fig. 7-12: Prostrate spotted spurge. Note milky juice on the broken stem.
7-13: Yarrow.

Fig. 7-13: Yarrow.

7-14: Yellow wood sorrel.

Fig. 7-14: Yellow wood sorrel.

7-15: Hawkweed.

Fig. 7-15: Hawkweed.

Fig. 7-15: Oxeye daisy.
7-16 and 17-16a inset: Red (or sheep) sorrel.

Fig. 7-16: Red sorrel.

7-17 and 7-18: Common mullein.

Fig. 7-17: Green foxtail.

Fig. 7-18: Yellow foxtail.

7-19: Henbit.
7-23: Clover

7-24, 7-24a inset and Fig. 7-24: Nimblewill.

7-25: Speedwell

Fig. 7-25: Pineapple weed.

7-26 and Fig. 7-26: Prostrate knotweed.
7-27 and Fig. 7-27: Purslane.

Fig. 7-28: Crabgrass.

Fig. 7-29: Smooth crabgrass.

7-28: Crabgrass mowing height demonstration. White stakes designate crabgrass seedlings.

7-29: Crabgrass per ft² at one-inch mowing height.

7-30: Ground ivy.
**WEED CONTROL MEASURES**

The primary control methods for weeds in turf are prevention, cultural, mechanical and chemical control. Biological control methods are being researched. Some show promise but are not commercially available at this time.

**Prevention Practices:** Include any method that prevents the introduction of weed seeds or vegetative parts into a turf area. Certified weed-free seed, sod, sprigs or plugs ensure that no additional weeds are introduced into a newly established turf area. Use of weed-free mulch, top-dressing and topsoil reduces the threat of weed introduction into turf area. Salt marsh hay is a desirable mulch because of its low weed content. Straw is an acceptable, lower-cost alternative to salt marsh hay, provided that the weed content is low. Inspect the straw before use to ensure low weed content. Hay should be avoided as mulch for turf because it contains the seeds of tall-growing, coarse-textured cool-season grasses such as orchardgrass, quackgrass, timothy and non-turf types of tall fescue. These grasses are perennials and, once established, they impart a non-uniform texture and color differences in fine-textured turf areas. They are extremely hard to control, short of total vegetative kill of the areas and reestablishment. New mulching products such as PennMulch provide good alternatives to hay and straw mulches. Sanitation practices should be followed particularly after mowing operations. Mowers pick up weed seeds. The decks and wheels should be cleaned after use to avoid transport of weed seeds from one turf area to another.

**Cultural Practices:** For weed control, include all management decisions that produce a dense, healthy turf that prevent weed seeds from germinating or surviving as seedlings. Although most weeds are highly competitive when mature, they are often poor competitors for light at the seedling stage. The following are selected cultural practices that should be considered an important part of a cultural weed control practice in turf.

**Turfgrass Selection:** Turfgrass not adapted to the conditions and intended use of the turf usually becomes weak, resulting in a thin stand that opens the opportunity for weeds. For example, there are turf mixes for sunny or shady conditions.

**Seedbed and Sodding Establishment:** Adequate and uniform coverage of the seedbed with seed of appropriate turfgrass species and cultivars prevent open spaces for weed development and provide competition for weed seedlings. Correct sodding techniques prevent gaps or seams where weeds could grow.

**Liming and Fertilization:** Soil pH that is too high (alkaline) or too low (acidic) or inadequate fertilization lessens the competitiveness of turfgrasses. Use an appropriate amount of nitrogen for the selected turfgrasses, but avoid excessive rates. Based on soil test recommendations, provide phosphorus at establishment and potassium during stress periods if needed.

**Mowing Practices:** Improper mowing heights and frequencies are 2 of the most common causes of weed infestations. Mowing too short and too frequently for some turfgrasses results in a weakened stand and increases weed encroachment as the stand thins. Low mowing allows increased light to reach weed seedlings. On the other hand, mowing too high allows for more weed seeds to be produced because seedheads are not removed in a timely fashion. Dull mower blades result in decreased turf density with time and increased weed encroachment as the stand thins out.

**Irrigation:** Improper watering contributes to weed infestations. Frequent light watering encourages shallow rooting and promotes weak turf. Over-watering increases the susceptibility of the turf to insects and diseases, which
decreases the turf density. Frequent irrigation also encourages germination and development of weeds at the expense of desirable turfturfs. Proper irrigation, both the amount and timing, is necessary during severe drought to prevent turf death.

**Turf Pests:** Damage to turf from diseases, insects, nematodes and certain mammals weakens or kills turfgrass, producing open areas that encourage weed infestations.

**Mechanical Control Practices**

These include methods that physically remove or destroy weeds. Tillage and cultivation are used effectively prior to turf establishment, but are not practical once turf is established. On small, localized areas, hand pulling and hoeing can be used in established turf, but are labor intensive and tedious and not practical on larger areas. Recent equipment developments using steam heating for control of certain weeds, particularly annuals, may be feasible in some turf situations. Mowing is a good control method for tall annual grassy weeds or tall broadleaf weeds, but usually is ineffective against low growing weeds such as annual bluegrass, nimblewill, goosegrass, crabgrass, purslane, prostrate knotweed, prostrate spurge, chickweeds, dandelion (but will reduce seed production), speedwells and ground ivy.

**Biological Control Methods**

These use living agents to manage weeds. Development and use of biological weed control agents in turf lags behind many other crop production systems, but there is research being conducted in this area. To date, the most promising bioherbicide for a turf weed is *Xanthomonas campestris* pv. *poannua*. This bacterium selectively infects and suppresses the growth of annual bluegrass without infecting desirable turfgrass species. A commercial product, XPo, is available to qualified customers under the Environmental Use Permit (EUP) from the EPA and registration is pending. It is anticipated that additional natural weed control products and bioherbicides will be developed because of the demand for such alternatives to conventional herbicides.

**Chemical Control Methods**

These include both natural and synthetic compounds, called herbicides or growth regulators, which kill or alter the normal growth of weeds. These materials include a wide range of chemical families and compounds that are used extensively in turf. When using herbicides, it is important to understand the difference between generic or common names and trade names of herbicides. The generic name of an herbicide is the active ingredient contained in the product. The trade name is the proprietary name of a product given by a company, which has exclusive use of that name. For example, 2,4-D is the generic name of an herbicide used for broadleaf weed control in turf and Weed-B-Gon is one trade name of a product that contains 2,4-D. Another example is Roundup, which is the trade name for an herbicide used for total vegetation kill. The generic name of the active ingredient in Roundup is glyphosate. Typically, generic names appear in lowercase, whereas trade names begin with a capital letter.

Herbicides can be classified based on their selectivity of killing action. **Selective herbicides** control or suppress certain plant species without seriously affecting the growth of others. In turf, it is important to control broadleaf weeds without affecting the desirable turfgrass species. One example of a selective herbicide is Banvel (dicamba), which is used to control broadleaf weeds in turf but does not affect turfgrasses under most conditions. **Nonselective herbicides** give total vegetation control; both grasses and broadleaf weeds are killed (including desirable turfgrasses, if present!). These materials are used for renovation where complete sod kill is desired or as spot treatments where weeds are not controlled by selective herbicides. An example of a nonselective herbicide is Roundup (glyphosate).

Timing of herbicide application is important in a turf weed control program. Herbicides can be applied as a preemergence treatment, prior to seed germination and emergence of weeds. Usually, **preemergence herbicides** are applied to the soil to form a barrier near the soil surface that kills the developing weed seedling. Preemergence herbicides are not effective against perennial weeds or weeds that have already emerged. They are formulated as liquids or as granules and need to be watered into the soil following application. An example of a preemergence herbicide is Baricade (prodimine), which is used to prevent crabgrass in established turf. Following an herbicide application, avoid raking, aerating or slicing which disturbs the protective chemical barrier.

**Postemergence herbicides** are applied after the weeds have emerged from the soil, and are used for control of broadleaf weeds and/or certain grassy weeds. Postemergence herbicides are usually formulated as liquids. They are often mixed with a surfactant (surface active agent), such as a spreader or sticker that increases the leaf contact area, providing for better efficacy. These materials are less effective if washed off the foliage by rainfall or irrigation. Therefore, application of postemergence herbicides should be timed according to weather forecasts or irrigation schedules. Postemergence herbicides provide either contact or systemic activity.

**Contact herbicides** affect only the portion of green plant tissue contacted by the spray (photo 7-33). They are typically fast acting, but the herbicide is not translocated throughout the weed. Therefore, underground vegetative parts are not normally killed. Contact herbicides are effective against annual weeds or seedlings of perennial weeds. They only give temporary aboveground control of mature perennial weeds and repeated applications are necessary for
these types of weeds. An example of a contact herbicide used in turf would be Reward (diquat).

Systemic herbicides are translocated in the plant’s vascular system and are slower acting than contact herbicides, often taking several days or weeks before visual symptoms are noticeable. However, they generally provide much better control of perennial weeds because of their translocation into underground vegetative structures. Systemic herbicides can be either selective (e.g., 2,4-D) or nonselective (e.g., glyphosate).

Recent concerns over the use of synthetic herbicides have created a demand for natural or organic compounds that control weeds. Herbicidal soaps (fatty acid solutions) are commercially available for use on turf weeds. They are effective, but are not selective. This precludes broadcast applications for most cases and limits their use for spot treatments only. They are contact materials and do not translocate throughout the weed. Corn and wheat gluten meal, the protein fraction of the grain, is extracted during the milling process. Controlled laboratory and greenhouse studies have indicated to varying degrees that corn gluten meal and wheat gluten meal reduced shoot and root development of several turf weeds. More studies are needed on these products, however, because control has been inconsistent under field trials.

When Are Herbicides Necessary?
This is an important question and varies depending on the goals and intended use of the turf area. Herbicides should be used within an IPM program, but should not be relied upon as the sole weed control method. Use of an action threshold for weeds in turf, similar to that used for control of insects in turf, would be a useful guide in determining when herbicides need to be applied to turf areas. The National Park Service (NPS) has issued guidelines for the application of herbicides on park grounds based on turfgrass use classifications and percent weed infestations in turf areas. Turfgrass classifications by the NPS are given as 3 categories: Class A Ornamental turfgrass; Class B Recreational turfgrass; and Class C Greenspace turfgrass.

Class A Ornamental turfgrass – Lawns classified as ornamental have the highest visual quality objective. Turfgrass must appear uniform in color and texture with weeds and bare spots unnoticeable to the general public. Ornamental lawns are exposed to minor foot traffic and receive the highest level of maintenance. Ornamental lawns provide the setting for memorials and other significant sites and features. Considering the intensive maintenance these areas require and that visual quality necessitates limited visitor use, managers should restrict the Class A designation to the minimum area necessary to achieve the visual management objective. Many commercial and residential lawns, most golf course turf, high-end sports facilities and sod farms in Connecticut would be considered as Class A turfgrass.

Class B Recreational turfgrass – Turfgrass that provides the setting for certain passive recreational and athletic activities can be classified as recreational turfgrass. Class B areas would include small urban parks and some playing fields for organized sports, as well as turfgrass surrounding offices, parking lots and other support facilities. Although such areas may have ornamental significance, the visual quality and level of maintenance is less demanding than ornamental turfgrass. Visitor use is common and some weed infestation is tolerable. The uniformity in color and texture is not as critical as in ornamental areas. Most parks and municipal recreational or school fields in Connecticut would be considered as Class B turfgrass.

Class C Greenspace turfgrass – Greenspace turfgrass encompasses large areas that receive minimal maintenance other than mowing. The aesthetic objective for the site is achieved simply by the presence of turf and not by its quality. Greenspaces would include large picnic and informal recreation areas, parkway medians, roadsides, cemeteries and conservation areas.

The following table summarizes the herbicide treatment options based on turfgrass class and percent of weed cover used by the National Park Service.

<table>
<thead>
<tr>
<th>% Weed Cover</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% to 14%</td>
<td>Cultural</td>
<td>Cultural</td>
<td>Cultural</td>
</tr>
<tr>
<td>15% to 29%</td>
<td>Spot</td>
<td>Cultural</td>
<td>Cultural</td>
</tr>
<tr>
<td>30% to 49%</td>
<td>Recovery</td>
<td>Cultural</td>
<td>Cultural</td>
</tr>
<tr>
<td>50%</td>
<td>Renovation</td>
<td>Renovation</td>
<td>Cultural</td>
</tr>
</tbody>
</table>
Definitions used within the body of Table 7-1 by the NPS are as follows:

**Cultural.** Any management practice or decision discussed in the previous section on control methods.

**Spot treatment.** Spot treatment may be considered when an action threshold of 15% to 29% weed cover is reached. Treatment must be limited to those areas that have reached the action threshold and can be sprayed with a backpack or other similar single nozzle, small capacity sprayer.

**Recovery treatment.** An action threshold of 30% to 49% weed cover indicates a possible need for broadcast application of herbicides by backpack or tractor-mounted, multi-nozzle boom sprayer. Treatment must be preceded by a complete review of the turf management program to determine why the weed level reached the recovery action threshold. The review examines the level of use, compaction, turf cultivar, mowing height, moisture management, fertility, pH and other factors considered pertinent to maintain Class A turf. Herbicide applications must be used in conjunction with other tactics to remedy the management deficiencies or site factors responsible for weed infestation. Recovery treatments are not generally approved for consecutive years.

**Renovation.** When the action threshold reaches 50% or greater weed cover, complete renovation may be warranted (except for Class C). Renovation is preceded by broadcast application of glyphosate or other similar broad-spectrum, post-emergent, short-residual herbicide that kills all vegetation. The treatment must be preceded by review of the overall turf management program as described for recovery treatments. The site is seeded or sodded as appropriate. All other management or site deficiencies determined in the review must be corrected.

There are many situations in Connecticut where the above threshold action levels could be used in turf areas. The guidelines used by the NPS are reasonable, and should provide an adequate starting point for a turf weed IPM program in Connecticut.

**MOSS IN LAWNS: CAUSES AND CORRECTIVE MEASURES**

Moss is often viewed as a problem in the landscape. Many hours and a great deal of money may be spent in an attempt to remove it from a particular area. The results are minimal if the cultural conditions favorable for moss growth are not corrected. The cultural conditions favorable for moss growth include one or more of the following: insufficient sunlight due to shade, an acidic or sour soil (low pH), low soil fertility, heavy or compacted soil or soil conditions that are too wet.

In the home lawn, the usual cause of moss growth is insufficient sunlight to support the turfgrass. When the shade is due to trees or shrubs, it may be possible to increase sunlight to the turfgrass by pruning and/or removing some of the plants.

Acidic soil conditions are often blamed for the presence of moss. Many people make rather heavy annual applications of lime-in in an attempt to kill it. If conditions are favorable, e.g., heavy shade and/or moist-to-wet soil, moss grows quite nicely on limestone. Have the soil tested before applying lime.

Soil with low fertility levels does not produce a vigorous turf. Weak, thin turf provides niches for weeds with lower nutrient demands. Mosses have a low demand for nutrients. A soil test will determine the levels of the major nutrients. The soil test report suggests the amount of nutrients to apply to correct the shortcomings that have prevented normal turfgrass growth.

Heavy or compacted soil, as well as excessively wet soil, has low oxygen levels. Oxygen is necessary for good turfgrass root growth. Compacted soils can be aerated with a spoon or core-type aerator. Heavy soils (soils with a high clay or silt content) have a tendency to become compacted and waterlogged. Tilling a few inches of coarse, sharp sand into the existing soil can make an improvement in texture and aeration. The addition of sand should be done carefully – too little sand can turn the area into a concrete-like mixture. Incorporation of a few inches of decomposed organic matter also helps. Where the clay content of the soil is high, tilling in 100 pounds of calcium sulfate (gypsum, land plaster) per 1000 ft² could aid in improving the structure of the soil. Well-structured soil is usually well aerated.

Where the soil is wet for long periods of time due to a high water table or a shallow hardpan layer, it may be necessary to drain the offending water or grow plants suitable to the site. As mentioned previously, the placement of drain tiles and/or curtain drains should only be done by persons knowledgeable with their installation.

Moss can be eradicated by mechanical or chemical methods. Raking with an iron rake or scraping removes the moss. An application of one of the moss control products that contain potassium salts of fatty acids or iron sulfate, gives short-term control of moss.

Killing the moss and failing to correct cultural conditions that favor moss growth leads to re-infestation. If it is impossible to correct the conditions, consider keeping the moss as a permanent low maintenance groundcover or plant another groundcover such as Japanese pachysandra (Pachysandra terminalis), English ivy (Hedera helix) or common periwinkle (Vinca minor), which are shade tolerant. Roughstalk bluegrass (Poa trivialis) can be planted in wet sites because of its tolerance to wet and shaded conditions.
For specific herbicide recommendations, consult the Professional Guide for IPM in Turf for Massachusetts. This is available through the University of Connecticut Cooperative Extension System.

REFERENCES

Penn State University
www.agronomy.psu.edu/Extension/Turf/WeedMgmt.html


Chapter 8: Turfgrass Diseases and Cultural Problems

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There are a number of common fungal diseases that afflict turfgrass. Some of them are serious and cause plant death, while others only impact the aesthetic quality of the turf. A simple way to understand disease outbreaks is to consider the “disease triangle.” The 3 components of the disease triangle are the host, the pathogen and the environment. Certain diseases are specific to individual turfgrass species, while others can attack multiple hosts. The fungal pathogens that cause the following turfgrass diseases are all common in Connecticut, although they may not be present in every turf area. As you review each disease, you will notice that each is only active when certain environmental conditions are present – those that favor the disease over the growth of the turfgrass. If one or more of the 3 disease triangle components is missing, then there cannot be a disease outbreak.

One reoccurring theme that is present under the prevention section for all of the diseases is the importance of sound cultural practices. Poor cultural practices predispose the turf to outbreaks of one or more turf diseases. For example, excess soil moisture favors root pathogens such as summer patch, while overfertilization with nitrogen promotes rapid growth of weaker leaf blades that are more susceptible to foliar pathogens, such as brown patch. Another cultural practice that can influence disease outbreaks is mowing. Mowing when the turf is wet moves foliar pathogens around the lawn (leaf blades collect on underside of mower) compared to mowing when turf is dry.

Injury to the turf itself is called a symptom. A symptom would include leaf spots, leaf discoloration, root and stem rots, or death of leaves or entire grass plant. As you will see, many of the turf diseases share similar symptoms. Often, the fungus produces visible signs on the turf. Signs include white mildew on the leaves; white, fluffy mycelium (thread-like, actively growing fungal structures); or red to black colored spores on the leaves.

The symptoms of turfgrass diseases can be similar to injury caused by stressful environmental conditions and or specific insect pests. In order to confirm the presence of a pathogen, turf samples should be taken to a disease diagnostic lab or analyzed with a test kit. Samples should be taken from the transition zone between healthy turf and discolored or dead turf. The pathogen is most likely to be active in this area. The Connecticut Agricultural Experiment Station has diagnostic laboratories at the main office in New Haven and the Valley Laboratory in Windsor. The University of Connecticut Home and Garden Education Center in Storrs is also a diagnostic facility. The test kits are designed for use in the field to confirm the presence of specific turf pathogens. Kits are available for gray leaf spot (Pyricularia grisea), Pythium, brown patch (Rhizoctonia) and dollar spot (Sclerotinia).
BROWN PATCH

Brown patch is a fungal disease caused by *Rhizoctonia solani*. It can be a problem in all turfgrasses, but in Connecticut it is most damaging to tall fescue, perennial ryegrass, creeping bentgrass and annual bluegrass. Brown patch favors hot (75°F to 95°F), humid and cloudy weather, nighttime temperatures above 68°F, and 10 hours or more of leaf wetness. Under conditions favorable to the disease, leaves can die in 12 to 24 hours. The disease is generally seen in summer and early autumn, although there are strains of this fungus that cause disease at other times of the year, such as *R. cerealis* that causes yellow patch or cool-season brown patch. Dense stands of well-fertilized turf are generally most susceptible to this disease.

**Symptoms**

Round or irregularly-shaped patches can appear very quickly on turf that is cut too short or on turf that is very wet. The patches may be small, or up to 20 inches or more in diameter. At first, the patches are purplish-green in color, but they soon fade to light brown (photo 8-1). If the weather is warm and humid, the fungus continues to invade new grass on the edges of the patch, so that there may be a dark purplish to grayish-brown border surrounding the spots. This sometimes is called a ‘smoke ring,’ and it is usually noticeable only in the early morning while the grass is still moist from dew. The ring consists of recently infected plants that have become covered with a web of fungal growth. The smoke ring is considered to be diagnostic of this disease. Symptoms for strains of this fungus that cause disease at times of the year other than summer and early autumn are generally light brown to yellow rings or patches.

On lawn turf that is cut at a normal height, the patches are light brown, and usually are round. There is no smoke ring. The affected grass usually lies flat to the ground, giving the patch a sunken appearance. The patches are usually about a foot across, but if the weather is wet, they may be enormous, up to 45 feet in diameter. In the center of the patch, the grass may recover because the crowns of the plants have not been killed or those plants may be unaffected. This pattern is sometimes called a ‘frog-eye’ and looks like a ring or doughnut.

On tall fescue, individual leaf blades show large discolored areas that extend from the leaf tip down the blade. These areas are tan in color and have a dark border (photo 8-2). Tiny, dark brown to black, hard structures may be seen in the thatch layer or in the leaf axils. These are the structures the fungus uses to survive the winter or dry conditions.

Proper Cultural Management

- Avoid excessive nitrogen fertilizer during susceptible periods.
- Keep the thatch layer less than one inch.
- Good drainage, both surface and subsurface, is necessary to keep canopy humidity to acceptable levels.
- Water early in the day to allow leaves to dry quickly.
- If possible, remove hedges, shrubs or trees to improve air circulation.

**DOLLAR SPOT**

The fungal species *Lanzia* and *Moellerodiscus*, which are often classified as the species *Sclerotinia homoeocarpa*, cause dollar spot. This disease is a common problem on golf courses, but rarely causes extensive damage to other turf areas. It attacks a number of turfgrass species, such as bentgrass, fescues, Kentucky bluegrass, perennial ryegrass and zoysiagrass. The disease is favored by warm (60°F to 90°F), humid (but not wet) weather; especially when nights are cool enough to cause heavy dew formation. This disease is
worse when the soil is dry and of low fertility. It is usually seen in late spring or late fall. It is not often seen in the summer. This fungus is quite persistent and patches often reappear in the same areas year after year.

**Symptoms**

On grasses that are mowed short, this disease causes small, circular, sunken patches in the turf (photo 8-3). These are generally smaller than 2 inches in diameter, about the size of a silver dollar. When the disease is severe, these patches can grow together to form irregular patches. The spots are first brown, and then become bleached or straw-colored.

On grasses that are mowed longer, such as home lawns, the patches are irregularly shaped. They are bleached or tan in color, and can be 3 to 6 inches in diameter. The patches may grow together to become quite large.

On individual blades of grass, regardless of how the turf is managed, the symptoms start as a yellowish spot. This spot then becomes water-soaked, and later bleached or straw-colored. The edges of the spots are generally tan to reddish-brown. On most grasses, the spots usually reach across the entire leaf blade, so that they look like a band across the blade. The discoloration is a very distinct hourglass shape (photo 8-4). There can be several spots on one blade and they may cause the entire blade to shrivel and die. Spots can start at the cut end of the blade and grow down. In the early morning, when the grass is moist from dew, the fungus may be visible as white, cottony, cobweb-like mycelium.

**Proper Cultural Management**

- Maintain adequate to high nitrogen and potassium levels in the soil.
- Avoid high levels of fertilizer in the fall.
- Mow regularly and at the correct height.
- Avoid drought conditions, but avoid allowing the plants to be wet for long periods of time.
- Water deeply and infrequently.
- Water early in the day to allow the leaves to dry quickly.

**FAIRY RINGS**

Fairy rings are caused by a number of soil-dwelling fungal species in the class Basidiomycetes. Their growth is charac-

terized by a circular or crescent-shape (on slopes) in the turf. The ring either consists of dead turf or healthy, dark green grass. As the fungi decompose organic matter in the soil, they release nitrogen in the form of ammonia. Other soil microorganisms turn the ammonia into a form of nitrogen that is useful to turfgrass. Thus, a dark ring of turf appears in the lawn. Fairy rings are most common in lawns growing in areas that had previously been forested, or have been filled with large amounts of organic matter. The pres-
ence of high-levels of organic matter provides the fairy ring fungi with an ample food supply.

There are 3 types of fairy rings:

- **Type I**: The ring is either dead or poor quality turf (photo 8-5).
- **Type II**: The ring is marked by dark green turf (photo 8-6).
- **Type III**: A distinct ring is marked by mushrooms or puffballs (fruiting bodies) growing in the turf (photo 8-7).

**Symptoms**

The most damaging fairy ring is **Type I**. The ring can range from a few inches to a couple hundred feet in diameter. In the areas marked by the ring, the turf may turn yellow, become stunted, or die. Often, there is increased turf growth in front and in back of the unhealthy turf area. This damage may be caused directly by parasitic activity of some of the fungi species on the turf. It could also be due to the fungal mycelium growing in the thatch and soil. The mycelium is hydrophobic (repels water), and thus, the turf growing in this area suffers from drought-like conditions.

**Proper Cultural Management**

- Fairy rings are hard to prevent and manage. One option is to accept their presence and learn to live with them. The presence of Type II fairy rings can be masked with core aerification, deep irrigation and proper fertilization of the surrounding turf.
- The only effective control option is the removal of the soil. Start the removal at least 2 feet to the inside and outside of the ring. Then remove the sod and soil to a depth of one foot. Take care not to spill the contaminat- ed soil. Fill the area with clean topsoil and then reseed or resod.

**Fusarium Root and Crown Rot (Fusarium Blight)**

Fusarium root and crown rot is caused by the fungus *Fusarium* spp. This disease can affect all turfgrasses of any age, especially Kentucky bluegrass. The disease progresses rapidly in hot, dry weather.

**Symptoms**

Small patches (2 to 6 inches) of turf become pale and may wilt. They first appear as slightly reddish areas, then tan, and finally become straw-colored. The patches can grow to 12 inches across and are irregular in shape (photo 8-8). A dark brown to black, dry, firm rot is present on the roots, crowns and bases of the stems. In warm, wet weather, white to pink masses of cottony to powdery fungal growth and spores may appear.

Leaf spots may or may not be present. If the spots occur, it will be during the warm days and cool nights of late spring into summer. They begin as irregularly shaped dark-green blotches, and quickly become light green, then reddish-brown, then dull tan. They have light colored edges. The centers may ultimately become bleached white. The spots can be almost 1/2 inch in length, and may reach across the entire leaf blade.

**Proper Cultural Management**

- Mow at the recommended height, mowing lower can stress the plants and predispose them to this syndrome.
- Remove thatch if it is greater than one inch.
- Remove clippings.
- Keep the pH of the thatch and the soil at 6 to 7 by adding small amounts of lime or sulfur regularly if necessary.
- Apply balanced fertilizers, and avoid deficiencies of phosphorous and potassium.
- Avoid excessive nitrogen, especially in spring and summer.
- Water as deeply and infrequently as possible.
- Water in the early part of the day to allow leaves to dry thoroughly.
- Including perennial ryegrass in mixtures of Kentucky bluegrass helps reduce the occurrence of this disease, and helps mask the disease symptoms.
GRAY LEAF SPOT
This disease is primarily a problem of warm-season grasses. It is active during warm, humid weather towards the end of summer. Gray leaf spot (*Pyricularia grisea*) has the potential to be a pest of perennial ryegrass in Connecticut. However, it is unknown how significant this disease will be on lawns.

**Symptoms**
Leaf discoloration begins as small brown spots that grow into an oval shape. With the larger spots, the center turns gray. This disease can progress onto leaf sheaths and the stem. The stem spots are a solid brown or black and lack the gray center.

**Proper Cultural Management**
- Mow at the correct height.
- Avoid application of excess nitrogen during hot and humid periods in the summer.
- Irrigate deeply and infrequently.

MELTING-OUT AND DRECHSLERA LEAF SPOTS
Melting-out is a fungal disease caused by *Drechslera* and *Bipolaris* fungi. The other name for this disease was *Helminthosporium* leaf spot. Kentucky bluegrass is the host for *D. poae* and suffers the worst damage. Fescue, ryegrass and bentgrass have similar leaf spots and crown rots caused by other *Drechslera* species. The primary activity is during the spring and fall.

**Symptoms**
This disease has 2 phases, the leaf spot phase and the crown and root rot, or melting-out, phase. Leaf spots occur during cool, humid weather in the spring and fall. Older leaves are more susceptible. Small, dark, round, reddish-brown to purplish-black spots appear on the leaves. A yellow ring may surround them. The spots grow to an oval shape. The centers die, turning light brown to almost white (photo 8-9 and 8-9a). On a few species, these fungi can cause a net-like pattern of brown streaks and spots. Spots may occur on leaves, sheathes and stems. In severe cases, the stem spots may completely encircle the stems and kill the plant above the spot. This can severely thin the stand (photo 8-10).

Warm, dry (or dry after wet) weather is favorable to the crown rot (melting-out) phase of this disease. On susceptible cultivars, the fungus may invade the roots and crowns, and cause a reddish-brown dry rot that later becomes black. The plants wilt, drop their leaves, and turn yellow to brown as they die.

**Proper Cultural Management**
- Plant resistant cultivars of Kentucky bluegrass.
- Apply fertilizer sufficient to encourage moderate growth.
- Avoid over-fertilization with water-soluble nitrogen fertil-
izer, especially in early spring and midsummer.
• Water early in the day, and as deeply and infrequently as possible.
• Mow grass as high as possible.
• Remove thatch in early spring if it is greater than one inch.
• Prune trees and shrubs to promote light penetration and air circulation.

**Necrotic Ring Spot**

Kentucky bluegrass, annual bluegrass and creeping red fescue are susceptible to necrotic ring spot (*Leptosphaeria koreana*). The pathogen primarily attacks the turf roots during cool, wet weather in the spring and fall. However, it can be active at all times during the year. This disease is often confused with the other root pathogen summer patch (on page 81) that is active only during the summer.

**Symptoms**

Early symptoms of necrotic ring spot are purplish colored, or wilted, turfgrass. The initial infestation can be hard to detect. Damage may not be evident until summer when the weakened turf grass starts to die from the root damage. The confusion with summer patch is that both cause dead turf areas with living grass in the center (photo 8-11). Necrotic ring spot patches are typically one foot or more in diameter, while the summer patch areas are usually less than one foot. Newly sodded lawns may be more susceptible than seeded areas.

**Proper Cultural Management**

• Mow at the recommended height for the turfgrass present.
• Remove thatch if it is greater than one inch.
• Keep the pH of the thatch and the soil at 6 to 7 by adding small amounts of lime or sulfur regularly.
• Apply balanced, slow-release fertilizers and avoid deficiencies of phosphorous and potassium.
• Avoid excessive nitrogen, especially in spring and summer.
• Water as deeply and infrequently as possible.
• Water in the early part of the day to allow leaves to dry thoroughly.

**Powdery Mildew of Turfgrass**

Powdery mildew, caused by the fungus *Erysiphe graminis*, affects Kentucky bluegrass and other bluegrass and fescue turfgrasses. This disease is favored by shaded conditions, especially if there is little air movement. Disease activity can occur any time days are warm (above 65°F) and nights are cool. It favors the cool, humid and cloudy weather of spring and early fall.

![8-11: Necrotic ring spot on Kentucky bluegrass.](image)

**Symptoms**

Whitish, talcum-like growth is present on the leaves and leaf sheaths, especially on older blades. The growth begins as small patches on the leaf, but covers large portions of the leaf if conditions are favorable for fungal growth. It grows more heavily on the upper leaf surface than on the lower leaf surface. Large patches of infected grass look as if flour or lime were sprinkled over them. If leaves are severely infected, they turn yellow, and then tan to brown as they die. The plants are weakened and may be killed by other diseases or drought stress.

**Proper Cultural Management**

• The use of shade-tolerant grasses in the mixture when planting in shady areas is key in preventing this disease.
• Some areas may be too shady to plant turf.
• If possible, prune trees and shrubs to allow more light to reach the turf and improve air circulation.
• Avoid excessive nitrogen fertilizer, but fertilize sufficiently to promote vigorous growth.
• Mow grass frequently, but relatively high in mildew-prone areas.
• Water as needed.

**Pythium Blight**

Pythium blight, caused by *Pythium* spp., is one of the most destructive turfgrass diseases. It affects most turfgrasses, especially annual bluegrass, bentgrass and perennial ryegrass. Mature stands of Kentucky bluegrass, tall fescue, fine fescue and zoysiagrass are usually not attacked by Pythium blight. Temperatures between 75°F and 95°F, surface moisture and high humidity favor this disease. Seedlings are particularly vulnerable. When *Pythium* attacks seedlings, it is called damping-off. Under the most favorable conditions, a stand of seedlings can be destroyed within 24 hours.
8-12: Pythium on perennial ryegrass.

8-13: Pythium mycelium on Kentucky bluegrass.

**Symptoms**

Round spots, 1 to 2 inches across, appear suddenly in hot, humid weather. The spots usually appear in clusters and develop very fast. Patches often grow together and their spread may follow the direction of water runoff or equipment movement. Patches are dark at first, then fade to a tan to reddish-brown color. When they are first infected, leaves are water-soaked, dark and slimy in the early morning. When they dry, they become reddish-brown, then tan and shriveled. If the humidity is high, the patches may become covered with fluffy, white, fungal growth (photos 8-12 and 8-13). When weather is less favorable, the leaves at the edges of the patches may have distinct white or straw-colored spots or bands on the blades. The edges of these spots or bands are the same color as the centers.

**Proper Cultural Management**

- It is important to keep the plants from remaining wet for excessive amounts of time.
- Provide good surface and subsurface drainage when establishing new sites.
- Avoid overwatering through deep and infrequent irrigation.
- Avoid watering late in the day or at night, when the leaves will not be able to dry.
- Remove thatch if it is more than 3/4 inch deep.
- Do not overfertilize, especially with nitrogen, but use a balanced fertilizer.
- Do not mow wet grass.
- If possible, prune trees and shrubs to increase air flow and light penetration.

8-14 and 8-14a: Red thread on Kentucky bluegrass.

8-14b: Closeup of red thread.

**RED THREAD**

The fungus *Laetisaria fuciformis* causes this foliar disease on annual bluegrass, Kentucky bluegrass, perennial ryegrass and fine-leaf fescue. Red thread causes damage to turfgrass growing under cool temperatures and insufficient nitrogen levels.
Symptoms

From a distance, the infected turfgrass areas appear as small, circular, brown patches. These areas may coalesce over time. Individual circular areas are 4 to 5 inches in diameter, but can range from 2 inches to 2 feet. A closer inspection when dew is present, or on a rainy day, will show red to pink fungal strands on the grass blades (photos 8-14, 8-14a and 8-14b). Red thread can also be present as pink, cottony puffs of spores on the turfgrass (photo 8-14c). When the fungus dries, the pink strands are still present though not as fleshy. Eventually, the pink mycelium strands (photo 8-14d) dry and turn bright red and fall into the thatch. High humidity, extended wet and overcast periods, and temperatures between 60°F to 75°F favor disease development. The disease spreads through growth to neighboring plants or movement by wind or equipment, such as a wet mower.

Proper Cultural Management

- Avoid mowing infected turf when wet.
- Increase nitrogen levels in the soil. However, fertilize at the correct rate based on results from a soil test and at the appropriate time. A late fall application makes the turf more susceptible to snow mold and winter desiccation.
- Avoid the use of perennial ryegrass if the disease persists.

RUST

Rust (Puccinia sp.) is a disease that affects almost all turfgrasses, but is most severe on Kentucky bluegrass (P. graminis), perennial ryegrass (P. coronata) and zoysia-grass (P. zoysiae). It is usually most severe on turf that is weakened from shade, drought, nutrient deficiency or improper mowing. Low light, wet leaves and temperatures of about 70°F favor this disease. The rust spores usually do not overwinter in Connecticut, but are blown in from the south each year. Thus, rust is most prevalent in late summer and early fall and not during the spring.

Symptoms

Light, yellow flecks on the leaves or stems become long,
yellow stripes that are parallel to the veins. They split open and spores are released. The spores range in color from orange to brick red, although they can be yellow to brown or black for some rust species (photos 8-15, 8-16 and 8-16a). When the infection is severe, the entire area may appear the color of the spores, and the spores may cling to hands, clothing or shoes. The turf may die in patches from the infection, or the stand may be thinned and weakened.

**Proper Cultural Management**
- In general, rusts cause less damage to turf when the grass is healthy and growing vigorously.
- Avoid water stress by irrigating during dry periods.
- Water early in the day to allow the leaves to dry before night.
- If possible, prune trees and shrubs to allow better light penetration and air circulation.
- Avoid mowing lower than the recommended height, as this can lead to stunted root systems and decrease the ability of the turf to withstand drought.
- Mow regularly to remove leaves before the spores are produced.
- Use a balanced fertilizer at recommended levels, as low nitrogen levels and nutrient imbalance can encourage this disease.

**SLIME MOLD**
Slime mold is an unsightly infestation caused on all turfgrasses by the fungal-like organisms, *Mucilago crustacea*, *Physarum cinereum* and *Fuligo* spp. They do not actually cause a turf disease, but can be very alarming when they suddenly appear. They use the stems and leaves of grasses to support their reproductive structures. Growth of these fungi is favored by prolonged wet and overcast conditions.

**Symptoms**
Round-to-irregular patches of grass may look as if they are covered with a slimy, creamy-white or greasy-black substance (photos 8-17 and 8-17a). This quickly becomes a powdery white, gray, bluish-gray, tan-to-orange, purplish-brown or black covering which can easily be rubbed off. Individual leaves can be covered with large numbers of pinhead-sized, fruiting structures of the fungi.

These organisms spend much of their lives as colorless or white, shapeless, slimy masses. They move from one place to another by “flowing” over the soil surface, thatch and plant surfaces. When they are ready to reproduce, they flow up the stems of grasses and produce the colored, pinhead-like structures, which contain spores. The spores are blown, carried or splashed to new plants, where they grow and eventually merge with each other to form the shapeless, slimy mass.

The affected patches of turf can be up to 2 feet across. Except for the actual presence of the slime mold, the grass is unaffected. It does not usually turn yellow or die. If the leaves are almost completely covered by a heavy infestation, some yellowing and weakening of the plants may occur. These plants may become more susceptible to pathogenic fungi. In a week or two, the growth usually disappears. It often reappears in the same place each year.

**Proper Cultural Management**
- There is usually little reason to control these fungi, as they cause minimal damage.
- Wash, brush or rake the leaves to remove the slime mold.
- Mow frequently if the grass is growing quickly to remove the fungus.

8-17 and 8-17a (inset): Slime mold.

**SMUT**
Stripe smut is caused by the fungus *Ustilago striiformis*. It affects many common turfgrasses, especially bentgrass and bluegrass. Kentucky bluegrass cv. Merion is especially susceptible. It is generally more of problem in established stands of turf than in newly seeded areas. It is often difficult to recognize this disease until the plants have been infected for at least 4 years, since the plants are usually scattered throughout the turf. This disease is favored by cool (50°F to 60°F) weather, and is usually a problem in spring and fall.

**Symptoms**
Stripe smut can form large patches in which most plants are infected. These patches may be up to 12 inches across. The disease can also affect individual plants scattered through-
perennial ryegrass and tall fescue can be attacked by these 2 pathogens. However, both diseases can be active without a snow cover. Cool temperatures and excess moisture during the spring or fall can cause infection. With no snow cover, pink snow mold is the only one that causes turf damage.

**Symptoms**
Turfgrass damaged by both snow molds turns grayish-brown. The grass blades in the infected areas collapse and become matted together. Turf damaged by gray snow mold has patches 3 inches to 2 feet wide (photo 8-19). The mycelium is gray colored, particularly at the edge of the patch, and most active on unfrozen turf. The survival structures of gray snow mold are orange-to-tan pellets about half the width of the grass blade. These can be used to identify the presence of this pathogen. Pink snow mold patches are smaller, usually 1 to

**Proper Cultural Management**
- Plant disease-free sod.
- Use seed mixtures that contain resistant cultivars to prevent devastating epidemics.
- Allow grass to undergo natural summer dormancy so that the infected leaves die. This may keep the spore production to a minimum, and decrease the number of future infections. Do this by withholding water and fertilizer during the hottest part of the summer.
- Avoid fertilizing excessively with nitrogen in the spring. It is important to apply a balanced fertilizer though to encourage vigorous growth, as this disease affects aging turf.

**SNOW MOLDS**
Gray snow mold (*Typhula incarnata*) and pink snow mold (*Microdochium nivale*) can develop under prolonged snow cover. Bentgrass, fine-leaf fescue, Kentucky bluegrass,
8 inches in diameter. When active, pink fungal mycelium can be found at the intersection of discolored and live turfgrass (photo 8-20). Pink snow mold invades the crown and kills the turf.

**Proper Cultural Management**

- Pink snow mold favors alkaline soil. Avoid raising the pH above 7.
- Avoid late season nitrogen fertilization that would cause lush turf going into winter.
- Fine and tall fescues suffer the least of all the susceptible turfgrasses.
- Once the snow has melted around an area with gray snow mold, rake and remove the affected grass.

**SUMMER PATCH**

Summer patch is caused by the fungus *Magnaporthe poae*.

It affects annual bluegrass, creeping red fescue and Kentucky bluegrass in warm weather, usually during the summer. The favored conditions are daytime temperatures above 88°F, adequate soil moisture and soil temperatures above 78°F. Most severe damage is on sunny, exposed slopes or any turf areas suffering from heat-stress. It is often prevalent in the early stages of drought stress that were preceded by wet weather in late spring or early summer. It tends to affect turf that is 3 years old or older. Although turf may recover in cooler weather, the affected areas grow slower, and are easily invaded by weeds.

**Symptoms**

Somewhat circular patches or crescent-shaped streaks of plants first become darker green than the surrounding turf. Then the plants wilt. White spots may appear on the leaves, usually as bands across the leaf. The leaves then collapse quickly, turn brown, and die. Patches are one foot or less across, but often grow together to form large, irregularly-shaped areas (photo 8-21). The center of the patch is often not affected, giving the patch a doughnut-like appearance, sometimes called a “frog-eye” (photo 8-22). The edges of the patches may blend into the surrounding healthy turf or may be very distinct. The edges may also be reddish-brown. The affected areas may be completely blighted or may have healthy plants mixed in with the dead ones. When the plants are dug up, the roots are dark brown to black, hard and dry-rotted. On the surface of the roots and crowns, a dark brown network of fungal growth can sometimes be seen.

**Proper Cultural Management**

- Mow at the recommended height. Mowing
too low stresses the turfgrass and predisposes it to summer patch.
• Remove thatch if it is greater than one inch.
• Keep the pH of the thatch and the soil at 6 to 7 by adding small amounts of lime or sulfur regularly.
• Apply balanced fertilizers and avoid deficiencies of phosphorous and potassium.
• Avoid excessive nitrogen, especially in spring and summer.
• Water as deeply and infrequently as possible.
• Water in the early part of the day to allow leaves to dry thoroughly.

ENVIRONMENTAL CONDITIONS AND POOR CULTURAL PRACTICES THAT MIMIC TURF DISEASES

There are a number of environmental conditions and cultural problems that cause turfgrass decline. Many of them cause the same general symptoms as turfgrass diseases and/or insect pests. Some of the following examples were mentioned briefly in chapter 6 on page 47.

Mowing with a dull blade shreds the end of the grass blade, or pinches it, instead of making a clean cut. The resulting injury is a frayed end that eventually turns brown. This discolors the entire lawn. Injury to the leaf blade causes unnecessary stress to the grass. This makes each plant more susceptible to heat, drought and disease.

Another mowing "disease" is scalping. A lawn cut too short appears brown because the upper thatch layer is more visible. As mentioned in previous chapters, turf mowed too low is stressed and more prone to disease, and weed seed germination increases because of the lack of shade from the turfgrass. Heavy feeding from sod webworm larvae or other caterpillars on the turf can also expose the thatch layer.

Fertilizer mishaps can cause a couple of turf abnormalities. If a drop fertilizer spreader is used, instead of a rotary style, and the wheels are not overlapped after each pass through the yard, streaks of light and dark colored turf appear. Dark green strips of turf appear where the spreader passed over, while paler-green strips are seen where no fertilizer was applied (photo 8-23). Also, fertilizer can kill turf areas. Heavy fertilizer spills that are not meticulously cleaned up burn the turf. This area of brown, dead turf may be mistaken for a disease or insect problem. Always fill the fertilizer spreader on a driveway or sidewalk. Man’s best friend can cause a “patchy disease.” Dog urine burns turfgrass just like a fertilizer spill (photo 8-24). However, there will probably be a number of discolored or dead turf patches associated with a dog, and typically one large burn area with a fertilizer spill.

Drought stress is the most common environmental condition that can be mistaken for a pest, or can hide true pest damage. As cool-season turf enters summer dormancy, usually brought on by lack of rainfall, the grass turns a grayish color (photo 8-25). Shoe prints remain quite visible on a drought stressed turf (photo 8-26). Eventually, the turf becomes brown and dry. Because of the brown color, sod webworm and chinch bug feeding damage may go undetected. When the turf starts to recover, these areas do not improve. Also, if the drought-stressed area is infested with a high population of white grubs in the late summer, the appearance will mask their feeding. The turf areas do not "green up" when adequate moisture returns because the roots have been eaten.

Salt damage to turf is often a problem in Connecticut with turf near sidewalks, highways or driveways because of the use of deicing materials. Deicing materials containing Na chlorides are the most destructive. Less damage results from the use of Ca or Mg salts. Salt damage to turf also occurs with urine patches from dogs or other domestic pets. In these situations, salt damaged turf can be remediated by applying gypsum (CaSO₄) or magnesium sulfate (Epsom salts) at (50 lb/1000 ft²), then reseeding or resodding. Gypsum and epsom salts act by causing the replacement of Na on the exchange sites in the soil with Ca and Mg, which promote the formation of soil aggregates.
(floculation). Sodium that is replaced on the exchange sites becomes dissolved in the soil solution and is then available for leaching from the root zone. Irrigation will help to leach Na from the root zone.

8-25: Drought stress on an athletic field. 8-26: Shoe prints on a drought stressed lawn.

Thatch

Thatch is the layer of undecomposed or partially decomposed organic matter (rhizomes, stolons, stems and grass roots) located in between the actively growing portion of green vegetation and the soil surface. A thatch layer of a 1/4 to 1/2 inch is desirable. Thatch holds the turf together and provides it with resiliency. Wear tolerance is greater where the desired amount of thatch is present. It also protects or insulates the soil from temperature extremes. When thatch accumulation becomes excessive, the disadvantages far exceed the advantages. When thatch exceeds 1/2 to 1 inch, implement control to reduce the potential for future problems. Turfgrass decline associated with excessive thatch is more an indication of poor turf management than any specific problem.

Problems Associated With Thatch

Excessive thatch accumulation increases the incidence of disease problems such as melting-out, summer patch, and Fusarium root and crown rot. It contributes to localized dry spots, decreases turfgrass vigor, makes the lawn more prone to scalping, and decreases heat, cold and drought hardiness. Thatch is also an unsuitable medium to seed into.

Thatch restricts the downward movement of water, air, fertilizers, limestone and pesticides. Thatch acts as a sponge and holds excessive amounts of water for extended periods of time. This reduces the oxygen supply to the roots and provides the ideal microenvironment for the development of disease causing organisms such as brown patch, leaf spot and dollar spot. In contrast, when thatch dries out, it resists water infiltration and does not allow water to reach the soil surface after an intensive rain or irrigation. This makes the turf more prone to drought and other stress (photo 8-27).

Insects such as chinch bugs, sod webworms and bluegrass billbugs can be found in thatch accumulations and can increase the need for insecticide applications. Insecticide effectiveness against soil-dwelling insects such as white grubs, can be less effective or non-effective when thatch is excessive. Certain insecticides are absorbed by the organic matter and do not reach the target pest in the root zone. This is one reason why insecticide applications for white grubs often fail to provide adequate control.

Also, turfgrass with excessive thatch is more prone to scalping. Scalping is the removal of an excessive amount of grass leaves at any one cutting, producing a stubby, brown lawn. The mower tends to sink into the thatch thereby lowering the intended height of cut, which causes the mower to scalp the turf. Scalping is accentuated or enhanced by high nitrogen fertilization levels. Thatch also reduces tolerances to heat, cold and drought that can reduce turfgrass vigor.

Factors that Cause Thatch Development

Thatch develops when the accumulation of dead organic matter from the actively growing turf exceeds the rate of decomposition. Any cultural or environmental factor that
either enhances excessive turfgrass growth or impairs the decomposition of plant parts causes thatch to increase. Factors such as low soil pH, poor aeration, excessive nitrogen levels, vigorously growing turfgrass cultivars and infrequent or excessively high lawn cutting are all reasons to explain thatch accumulation. Remember that lawn clippings do not contribute to thatch accumulation.

One of the reasons for thatch accumulation is the overstimulation of plant growth. Excessive nitrogen fertilizer applications stimulate growth to the point where growth exceeds the decomposition rate of the thatch. This is commonly seen on home lawns that are fertilized 4 to 5 times per year. Often, these applications are being made by professional lawn care companies that do not take into consideration other cultural practices such as mowing, watering, soil testing, core aerification and dethatching.

Certain turfgrass cultivars are quite vigorous. This is important in tolerating high traffic and assuring good recuperative potential. Associated with this increased vigor is the potential for quick thatch build up. The vigorous growth habit of grasses, such as creeping bentgrass, and Kentucky bluegrass, that produce creeping stems and rhizomes, have a tendency to produce more thatch. The turfgrass manager should know when these cultivars are being used and implement the appropriate cultural practices to prevent thatch accumulation. A slow-growing turfgrass may also be prone to thatch build-up, but for a different reason. These cultivars produce tissue that is more resistant to decomposition, which also contributes to thatch development. The decomposition rate can vary depending on turfgrass species. Some species with high lignin content, such as fine leaf fescue, may also accumulate thatch faster under a moderate fertilization program.

Thatch decomposition decreases when soil pH falls below 6.0. Acidic soil conditions decrease microorganism activity, which is necessary for decomposition. Low oxygen levels from compacted soils, dry soils and some pesticide applications can also decrease microorganism activity. Soil temperatures of 70°F to 100°F and moist soil conditions favor optimum microbial activity.

**Thatch Removal**

Thatch should be removed when levels exceed 1/2 to 3/4 inch for home lawns. To evaluate the depth of thatch, take a knife and cut the turf 4 to 6 inches on 3 sides to make a flap. Pull back the turf to examine and measure the thatch layer. This determines whether to implement thatch removal measures. Established lawns may require thatch removal on a yearly basis. Thatch removal can involve mechanical or biological methods.

**Vertical Mowers**

Mechanical thatch removal can be done through the use of a vertical mower (photo 8-28). This is also referred to as a “power rake” or “dethatcher.” This has been a standard method of thatch removal for many years on managed turf. A vertical mower uses vertically operated blades arranged on a horizontal rod that cuts into the turf perpendicular to the soil surface. It is a rather intensive method that pulls out thatch and thins the turf immediately. This intensive type of dethatching is usually done when higher levels of thatch exist. Vertical mowing should only be done in spring and late summer, during times when turfgrass shoots and roots are actively growing in order for the turfgrass to recover.

The amount of thatch that can be removed at one dethatching depends on the size and weight of the vertical mower. Vertical mowers rented to homeowners are relatively lightweight, have a small power
unit and are easily lifted and transported. This type of vertical mower usually require the unit to be operated 2, 3 or even 4 times in varying directions, in order to remove a significant portion of the thatch. After the thatch has been loosened, rake up thatch debris and remove it from the lawn. New laws in Connecticut prohibit grass clippings and plant debris from town recycling centers. This may restrict vertical mowing in certain situations where disposal of the debris is a problem. Topdressing and overseeding can also follow vertical mowing as a means to add organic matter and introduce improved turfgrass cultivars.

Coring

Another mechanical method of managing thatch is core aerification or coring. Core aerification is an effective, but less intense way of managing thatch accumulations. Core aerification is also an effective tool for managing soil compaction. Coring involves the use of a hollow or spoon-type tine that removes soil cores and leaves a hole in the turf. The diameter of the coring tine can vary from 1/4 to 3/4 of an inch. In terms of spacing, there should be a core hole approximately every 2 inches in the turf surface. The depth of the corer can be from 3 to 4 inches. Soils in Connecticut traditionally have an abundance of stones. Stones, even small ones can limit the depth of the aerator or cause damage to the aerator tines. Core aerification is better used when thatch levels are at 1/2 inch or less.

There are 2 different types of core aerifiers. The first type involves semi-open spoons or tines mounted on a circular drum with the cores removed by the rolling action of the drum. This type of aerator most likely will not produce enough holes with one pass and generally requires several operations in varying directions to achieve a core hole every 2 inches. This drum-type aerifier is the most common type available to homeowners. Turfgrass professionals also use this aerator type for athletic fields and other turfgrass areas.

The second type of core aerator is a unit where the hollow tines are mounted on a shaft that operates in a vertical motion. Its function is to pull cores of soil up out of the turf. The spacing of the tines is determined by the forward motion of the machine and the rate of vertical motion of the shaft. Generally, this type of aerator produces an adequate number of holes in one pass. They are commonly used to cultivate golf course greens and other professional turf surfaces.

The soil cores pulled out of the turf should be left on the lawn surface. Soil cores are generally moist and break apart within a few days. A drag mat, or hand rake can also be used to help break up soil cores. Coring can be done almost anytime of year, but it is best done when there is adequate soil moisture. Penetration of the tines is greatly reduced if the soil is dry and compacted. Coring accompanied with lawn renovation in late summer is an easy way to loosen compacted soil and incorporate improved turfgrass species and cultivars. Topdressing can be done in conjunction with coring. It is applied after coring has been completed.

Topdressing

Topdressing is the application of a thin layer of prepared soil to the soil surface. It is useful to manage thatch biologically and to level turf surfaces. It can also provide certain nutrients and microorganisms to stimulate growth and improve turfgrass color. The textural properties of the topdressing material should be similar to that of the soil at the site where topdressing is taking place. A topdressing of 1/4 to 3/8 inch is usually adequate for home lawns.

Biological Dethatching Agents

Biological dethatching materials are a nonmechanical means to control thatch. These products stimulate microorganism activity to decompose thatch. This method works slowly to help decompose up to 1/4 inch of thatch annually. The success of these materials is influenced by soil moisture and soil pH. A regularly irrigated lawn with a soil pH of 6.0 to 7.0 will produce the intended results from biological dethatching agents. These materials are relatively ineffectve when applied to dry soils, nonirrigated turf areas or acidic soil conditions. Therefore, the cost of the biological dethatchers is not justifiable under these conditions and traditional, mechanical methods of managing thatch are recommended instead.

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Chapter 9: Insect Pests of Turfgrass

Timothy M. Abbey and Dana Karpovich

There are numerous insect species that can be found in a typical lawn. Luckily, most of these are not major turfgrass pests. The following insects are key pests of turfgrass in Connecticut. In the next chapter, the beneficial insects that play an important role in the management of turfgrass insect pests are discussed.

The pest management professional and homeowner should be aware that there are other non-infectious agents that cause damage similar to diseases and insects. Some causes that cause turfgrass damage include misapplied pesticides, animal urination, bird salts, excess fertilizer, nutrient deficiencies, air pollutants, chemical spills, and soil compaction. If injury from one of these is misdiagnosed as pest activity, an unwarranted pesticide application may result.

Even though specific insecticides are not discussed for the following pests, there are some general comments to be made on the use of insecticides.

• Remember to always read the label and follow the application rates. Also, take note of any precautionary statements related to the product's adverse effect on beneficial insects, earthworms (extremely important for soil aeration) and aquatic invertebrates and fish.

• Note that broad-spectrum products kill a wide assortment of insects (including beneficials). Selective products are effective against a smaller number of organisms or life stages.

• Select the appropriate insecticide formulation (flowable, granular, wettable powder, emulsifiable concentrate) for the pest and location.

• Wear the required protective clothing.

SURFACE FEEDERS

Chinch Bug

General Description: The hairy chinch bug (Blissus leucopterus hirtus) is a small (less than 1/4 inch long), black bug with shiny white wings folded over its back. Nymphs vary in color as they mature, progressing from red with a white band, to orange, to orange-brown, and finally black (photo 9-1). All stages spend most of their time in the thatch layer.

Biology: Chinch bugs overwinter as adults in turf, thatch, under leaves, around foundations and in other protected areas. Adults become active during mid- to late April and immediately begin to feed and mate. Within a few weeks, females begin to lay eggs in leaf sheaths for a 2- to 3-week period. During the spring, eggs may take a month or longer to hatch; but, during warm summer months (over 80°F), eggs may hatch in as little as 7 to 10 days. As eggs hatch, nymphs begin feeding on turfgrass leaves and stems. Nymphs develop into adults over a 4- to 6-week period through a series of 5 instar stages. There are usually 2 generations per year in Connecticut, and sometimes more when warmer weather extends into autumn. The first generation of nymphs appears in early June. The second generation peaks in mid-August.

Damage: Chinch bugs have piercing-sucking mouthparts that remove sap from the host plants, which include bentgrass, Kentucky bluegrass, perennial ryegrass, red fescue, and zoysia grass. Insect feeding, primarily by the nymphs, causes plants to wilt and die. Damage initially appears as irregular patches of yellow grass that soon turn brown. As the feeding damage increases, the small patches of grass coalesce into larger areas of dead turf (photo 9-2). Feeding chinch bugs move to the border between living and dead grass, in order to feed on healthy plants. Adults may cause some damage in early spring. However, most damage to turfgrass results from the nymphs feeding from early June into September. Turf damaged by chinch bug feeding may also suffer from prolonged periods of hot, dry weather. Most turf that experiences this combination does not recover.

Monitoring and Action Thresholds: Chinch bug injury often appears first in sunny, dry areas on southerly slopes, or on turfgrass adjacent to driveways, sidewalks and other areas that radiate heat. Such locations should be closely monitored for chinch bug activity. Monitoring should be conducted at least once a month beginning in early June. An extended surveillance of the area provides more detailed information on the population. This helps with decision-making.

To monitor for chinch bugs, closely examine turfgrass on hands and knees and vigorously scratch the thatch/soil surface. Chinch bugs can then be seen moving through the disturbed area. Growing degree days (GDD) (see the sidebar on the next page) can be used to determine when to begin scouting. Guidelines were developed in New Jersey for a chinch bug population with 2 generations per year. A baseline temperature of approximately 59°F
WHAT ARE GROWING DEGREE DAYS?

It is virtually impossible to give exact calendar dates for when specific insects first become active during the year. In most cases, insecticides should not be applied on a calendar date basis. Optimum timing of needed treatments may vary from year to year depending on the environmental conditions, the degree of winter protection obtained from shelter, and the inherent differences among individuals.

Because insects are cold-blooded, they take on the temperature of their immediate environment. Thus, at warmer temperatures, insects complete their life cycles at faster rates than when they are exposed to colder conditions. In temperate regions, such as Connecticut, many insects and plants go through a dormant period to survive the winter. Because of the relationship between insect developmental time and temperature, growing degree days (GDD) can be used to help predict the occurrence of specific stages in the life cycles of certain insects.

Accumulation of GDD can be used as a guideline to target the best times for scouting or, in some cases, the timing of treatments. GDD should not be used as a substitute for scouting because they provide no information on whether or not a pest is actually present at a given site, nor is any information provided on the magnitude of the infestation. They also cannot predict future weather patterns.

The GDD are expressed as a range of numbers, such as GDD: 190 to 290, to indicate when a pest is likely to be active or present in a given stage(s) of development. Scouting for the pest should begin in the early portion of the GDD range to detect any infestation before serious damage results. Repeat scouting periodically throughout the GDD range helps determine whether or not a control treatment is necessary.

To calculate GDD, use 50°F as the baseline temperature. Below 50°F, insect activity and growth is minimal. In New England, calculations should begin on March 1 and continue daily throughout the growing season. GDD accumulate by adding each day’s GDD to the total reached on the previous day. A maximum and minimum thermometer can be used to obtain the needed temperatures for each day’s calculations. If the average daily temperature is less than 50°F, then add zero. To determine the GDD for each day use the following formula:

$$GDD = \frac{(\text{Maximum} + \text{Minimum daily temperature}) - 50°F}{2}$$

There are only a few turf pests (chinch bugs, bluegrass billbugs) where GDD limits have been established. However, there are GDD for numerous insect pests of ornamental trees and shrubs.


was used. The first generation egg hatch was completed by 115 GDD. The second generation completed its egg hatch by 850 GDD.

Another sampling method is to use a 4-inch diameter cup cutter to remove a sample plug of turf (photo 9-3). Quickly, but gently, remove the soil from the sample and submerge the turfgrass portion in a pail of water (photo 9-4). If present, chinch bugs usually float to the surface within 2 to 4 minutes, but continue to monitor for up to 10 minutes. Samples should be taken from the edges of damaged areas where the grass is just beginning to turn yellow. Chinch bugs move out of the completely dead patches and into the transition area between dead and healthy turf. A third method that can be used is to remove both ends of a coffee can, push one end into the thatch and soil, and fill with water. If the water percolates through, keep filling the cylinder until the can holds water. Chinch bugs float to the surface if present.
An average of less than 20 chinch bugs (all stages) per square foot of healthy turf does not warrant treatment. Approximately 20 to 30 chinch bugs (all stages) per square foot require a site evaluation and a decision on whether or not to apply insecticides for control. If the turf is under stress from heat and drought, this range requires treatment. When there are more than 30 chinch bugs (all stages) per square foot, treatment is definitely warranted. Remember that action thresholds vary and serve only as a guide. They can fluctuate depending upon the overall turf health, environmental conditions and your experience with the pest.

**Sod Webworm**

**General Description:** Though there are several species of sod webworm, the authors have chosen to focus on the bluegrass sod webworm (*Parapediasia teterrella*), often referred to as the lawn moth, are white, gray or tan, slender and are 3/4 inch long (photo 9-5). When moths are at rest, the snout-like mouthparts are noticeable from the front of the head (photo 9-6). Their wings are rolled, tube-like and close to the body, which makes the moths appear very slender. Larvae vary in color from green, beige, brown to gray. Larvae are 3/4 inch in length at maturity; they have brown heads and a pattern of dark circular spots along the lengths of their bodies. Some species have 1 or 2 spiny hairs that project from each of the spots. Larvae have from 6 to 10 instar stages with 8 being the most common.

**Biology:** Sod webworms overwinter as larvae in silk tubes or sheaths that they form in the upper root zone. Larvae pupate in April and May, and adult moths appear in late spring to early summer. The moths are active in the evenings during June and females drop their eggs randomly as they fly in a zigzag pattern over the turf. Larvae feed in June and July; pupation occurs in July. Adults appear again during late July and August and lay the second-generation eggs. The larvae from this generation are active in August and September.
Damage: Since the adults do not feed, only the larvae cause damage to turfgrass. As soon as larvae hatch, they seek hiding places and conceal themselves by weaving particles of debris and silk strands around their bodies. Young larvae feed only on the surface of leaves and cause little damage. Older larvae chew notches in grass blades or chew the blades off just above the crown. The larvae feed only at night. Their preferred hosts include Kentucky bluegrass, perennial ryegrass and fine fescue. Damage appears as small irregular patches of brown turfgrass (photo 9-7). Usually, sod webworm feeding does not kill the crown. If the infestation is controlled and fertilizer and water applied, the lawn recovers in the fall. However, if the feeding took place on drought-stressed turf, the areas remain brown when improved growing conditions return (i.e. cooler temperatures, more moisture), while the surrounding areas return to the normal green color.

Monitoring and Action Thresholds: Walk through the lawn and note the number of moths that are disturbed. Adults spend the day resting, with the head down and wings and abdomen slightly raised, on grasses, broadleaf weeds, or nearby plants. At night, check the lawn with a flashlight or near any outdoor lights for adults. Commercially available black light traps can also be used to monitor adult flight activity. Once adult moths have been observed, wait approximately 2 weeks to scout for larvae. Visually inspect the thatch for larvae and silk tunnels. Larger larvae construct silken tunnels that are used for protection while in the thatch. Green excrement pellets found in the thatch are also an indication of the presence of larvae. A soap drench that consists of 1 to 2 tablespoons of liquid dish soap in 1 to 2 gallons of water can be spread over a 4-foot square area (photos 9-8 and 9-8a). Wait at least 5 minutes and watch for larvae crawling to the surface. Five to 10 larvae per square foot may require treatment. Each lawn may have a different threshold for aesthetic damage, which determines if controls are necessary. Ten to 30 larvae per square foot is a severe outbreak and causes turf damage. A non-chemical option for management is to replant damaged turf using high-endophyte turfgrass cultivars. (See page 101 for more details on endophytes.)

Armyworms and Cutworms

Occasionally other caterpillars cause damage to turfgrass. The black cutworm (Agrotis ipsilon), bronzed cutworm (Nepheleodes minians), variegated cutworm (Peridroma saucia), armyworm (Pseudaletia unipuncta) and fall armyworm (Spodoptera frugiperda) feed on cool-season grasses. The bronzed cutworm and armyworm are indigenous to the Northeast. In most lawn situations, these caterpillars should be considered a minor pest. For example, since fall armyworms do not overwinter in Connecticut, their populations can fluctuate greatly from year to year.

General Description: The adult stage of these pests are rather non-descript, brown, black or gray-colored moths. All of the caterpillars are stout-bodied and up to 2 inches long with few body hairs. Cutworms are dark brown to gray-colored with black spots on the sides of the body. Armyworm larvae (photo 9-9) have 3 pale stripes running down the body, one on each side and one down the center of the back. The fall armyworm caterpillar also has similar stripes. In addition, it has a yellow-colored, inverted Y on the front of the head.

Biology: The bronzed cutworm overwinters as eggs. The armyworm overwinters as pupae in the soil. The
other species do not overwinter in New England. They recolonize northern areas by flying in from the south each year. All species have 2 to 4 generations per year, depending on food availability, the environmental conditions and other factors, except for the bronzed cutworm that has only one generation per year.

**Damage:** Cutworms hide in the soil and thatch during the day and then feed at night. As they feed, they remove the blades and shoots, leaving circular, discolored areas.

Armyworms feed on the turf surface, usually in a group, which can result in more extensive areas of damage. Early armyworm damage appears as leaf skeletonization; later larval instars consume all of the leaf. Once the foliage has been removed, the exposed thatch layer gives the area its brown color. The damage is similar to sod webworm damage, but it develops quicker because of the increased caterpillar size.

**Monitoring:** The detection of these pests, particularly cutworms, can be difficult because they are nocturnal feeders and hide quite effectively. A soap flush, similar to the one for sod webworm larvae, can help locate these pests. Also, a visual search through the grass and the holes in the soil, and under plant debris will locate caterpillars. Armyworms do not remain in one location for their entire development, and turfgrass located near crop fields (corn, oats, wheat, etc.) is the most susceptible to attack.

Like sod webworms, armyworms are not expected to reach pest status in high-endophyte grasses.

### Root Feeders

#### Bluegrass Billbug

**General Description:** Adult bluegrass billbugs (*Sphenophorus parvulus*) are gray, black or brown weevils (photo 9-10). Newly emerged adults may be reddish-brown in color. The true color is often masked by dried soil on the insect’s body. They are 1/4- to 3/8-inch beetles that have chewing mouthparts located at the end of a long snout or “bill.” Larvae are legless white grubs with brown head capsules. All instars resemble each other except for their size. At maturity, larvae are about 1/3 inch long.

**Biology:** Bluegrass billbugs overwinter as adults that hibernate in patches of weeds, litter and other protected areas. They emerge over time from mid-May through mid-June, and may be seen crawling across sidewalks and paved areas. Adults feed on grass stems above the crown, and chew small holes in the stem to deposit the eggs. Eggs hatch in late May. Larvae are most active in July with activity decreasing in August. The bluegrass billbug has one generation per year.

**Damage:** Kentucky bluegrass is the primary host. However, damage has also been found on perennial ryegrass, fine fescue and tall fescue. Adults feed on grass stems, but their feeding activity is not regarded as a major concern. Young larvae begin feeding by tunneling inside grass stems. As larvae grow, they feed on the crown and, later, move to the soil to feed on roots and rhizomes. Damage results in irregular shaped patches of brown turfgrass (2 to 3 inches in diameter) similar in appearance to that caused by chinch bugs, drought stress or disease (photo 9-11). Billbug feeding however, produces fine, whitish sawdust-like frass (waste material), which can be found at the base of the plants (photo 9-12). Also, damaged plants easily break off at the crown when pulled, leaving the base and the roots of the plants and soil undisturbed. Damaged turfgrass first appears in late June into July, usually near a sidewalk or driveway.

**Monitoring and Action Thresholds:** The greatest impact on the population occurs when control measures target the adults. The presence of billbug adults is easily determined when adults are observed crawling over paved areas adjacent to turf, or when pitfall traps are used to collect beetles walking through the turf area. Monitoring for the adults...
should start by late April. During the spring, when 2 or more adults are counted per minute on pavement, damage in surrounding turfgrass can be expected. Scout in mid- to late April in southern and costal locations. The interior of Connecticut should see adults by mid-May. Treatment of turfgrass, in April through May for the adults, can prevent severe turf damage by the larvae later in the summer.

Pitfall traps consist of 16-ounce plastic cups placed into the ground so that the lip of the cup is at or just below (1/2 inch) the soil level. The easiest way to do this is to use a commercially available cup cutter. This tool is used on golf course to remove a soil core for placement of the hole on putting greens (photo 9-13). Three to 4 small holes should be punched into the bottom of the cup to allow water to flow out. If desired, a smaller cup can be placed in the larger one for easier removal of adults. To prevent the billbugs from crawling out, a smaller funnel-shaped cup, with the bottom removed, can be placed in the cup or the top of the 16-ounce cup can be greased (photos 9-14 and 9-14a).

Pitfall trap counts and associated damage thresholds are: 2 to 5 adults/day cause moderate damage, while 7 to 10/day cause severe damage. Check the traps a couple of times a week. Pitfall traps can be used in conjunction with GDD. Adult billbug activity is first noticed at 155 to 195 GDD. The last window of opportunity for controlling adults is 311 to 347 GDD.

The larval stage can also be monitored. Scout for damage in suspect areas in July. A cup cutter or hand trowel can be used to inspect for larvae. Look for larvae in the thatch and soil region. Larvae can be difficult to find at times. However, larvae produce sawdust-like material that can usually be found in the thatch. An action threshold of 5 or more grubs per square foot is an approximate threshold. Control of larvae is more difficult than for the adults. Treatment results vary depending on the material used and location of the billbug immatures.

**White Grubs**

**General Description:** The turf damaging insects known
as white grubs are the larval stage of several species of scarab beetles (Family: Scarabaeidae). Examples include the Japanese beetle (*Popillia japonica*), European chafer (*Rhizotrogus majalis*), northern masked chafer (*Cyclocephala borealis*), oriental beetle (*Anomala orientalis*) and the Asiatic garden beetle (*Maladera castanea*). Most white grub populations found in a turf area may consist of a mixture of species. In Connecticut, dominant species vary by location, but now the most common are the oriental beetle, European chafer and Asiatic garden beetle.

The adult **Japanese beetle** has a metallic-green head and thorax and copper-colored wings with tufts of white hairs around the edge of the abdomen (photo 9-15). The adults are almost a 1/2 inch in length. Adult emergence can begin as early as mid-June and peaks in early July. This beetle is a day flier that feeds on more than 300 species of plants. The feeding damage is very distinct where the leaf material is removed leaving the leaf veins. This is called skeletonization.

The **European chafer** is a light-brown beetle (about 1/2 inch or slightly more in length) that flies on warm nights starting in June (photo 9-16). The adults may be a nuisance to some homeowners when they aggregate around chimneys to find mates. They often drop down the chimney and attempt to burrow under the carpet. Luckily, the adult European chafer does not cause plant damage. The grubs of this pest are the largest of the common white grubs. These grubs cause the most serious damage to turfgrass because the larvae are larger than other species, feed later into the fall and start feeding again earlier in the spring. Because late instars are so big, these grubs must be controlled in the early larval instars. This species also feeds on the roots of ornamental plants.

The **northern masked chafer** has dark markings around the head that contrast with the 1/2 inch long, tan body (photo 9-17). Adults emerge in late June into July and fly at night. Like the previous species, grubs feed from mid-August through September. This pest is now uncommon in Connecticut.

**Oriental beetle** adults are almost 1/2 inch in length and have a wide variety of color patterns. They can be dark brown, straw-colored or have a mottled appearance (photo 9-18). Emergence begins in mid-June and the beetles are present in August. The adults do very little feeding, but can be found on daylily, dahlia, rose flowers and other plants. The grubs feed on both turfgrass and ornamental plant roots. Adult flight activity for oriental beetle can be monitored with skimmer filters of pools, since adult beetles are attracted to and are caught there.

The **Asiatic garden beetle** is small (approximately 1/4 inch), velvety brown with the hardened, front pair of wings (elytra) not completely covering the end of the abdomen (photo 9-19). The grubs of this beetle can be major turfgrass pests, but usually they are more important as pests of ornamental plants. Adults begin to emerge in late June. They feed on the leaves and flowers of over 100 species of plants primarily during mid-July to mid-August. This night-flying beetle hides under the plants it feeds on during the day.

The larvae of all the scarab beetle species are white in color with “C” shaped bodies, 3 pairs of legs, light brown heads and pro-
nounced mandibles (i.e. chewing mouthparts) (photo 9-20). Depending on the species, they range in size from 1/2 to 1 inch in length when fully grown. Grubs can be identified to species by examining the pattern formed by the spiny hairs on the underside of the tip of the abdomen. This area is referred to as the raster. The raster pattern varies by species and can be seen with a hand lens. Japanese beetle grubs have a V-shaped pattern. The European chafer has 2 rows of hairs that form a Y-shape. Northern masked chafer has no distinct pattern of hairs. Oriental beetle grubs have 2 parallel rows of hairs. The Asiatic garden beetle has a crescent-shaped raster pattern. See figure 9-1.

**Biology:** All of the common species of white grubs in southern New England have a one-year life cycle. Other species, such as the May or June beetles (Phyllophaga sp.) have 2- and 3-year life cycles. Beetles with a one-year life cycle deposit their eggs in the soil or thatch beginning in midsummer. Eggs hatch in early August and continue into September. Except for the European chafer which prefers drier locations, egg development is most successful in moist soil, such as in a well-irrigated lawn. Newly-hatched larvae feed on the fine feeder roots of grasses. Older grubs may consume a majority of the plant's root system. Feeding may continue throughout the fall and is dependent on soil moisture and temperature. As soil temperatures cool in late fall, grubs migrate downward into the soil and hibernate for the winter. Once soil temperatures drop below 50°F, downward migration stops. Most grubs overwinter in the third larval instar. The majority of grubs move downwards to a depth of 2 to 6 inches with fewer traveling 6 to 10 inches below the soil surface. In the spring after frost disappears and soil temperatures begin to warm, grubs migrate upwards to the root zone. Larval activity can be seen as early as March and continue through June. Grubs move slightly downwards in the soil to pupate. Depending on the species, the beetles emerge from the soil in early June and continue through mid-August. Adults may be most numerous in early July, but some individuals are present until the first killing frosts.

**Damage:** All turfgrasses present in New England serve as hosts for white grubs. All species, but especially the European chafer and the oriental beetle larvae, also feed on the roots of woody ornamental plants. Damage to turfgrass by feeding larvae can be devastating. Large areas of turf-
Damage of Japanese beetles is quite distinct. They remove leaf tissue while leaving the major veins. This is called skeletonization. The Asiatic garden beetle attacks boxelder, butterfly bush, Japanese barberry, viburnum, aster, dahlia and others.

**Monitoring and Action Thresholds:** For new properties, grub monitoring can be conducted in early August through September and in the following April through May. Adult beetles prefer to lay their eggs in sunny locations on well-managed turfgrass so focus in those areas. Once the property has been monitored for a number of years, a history of grub infestations becomes established. Knowing the key locations allows you to make appropriate management decisions.

For effective grub sampling, use a shovel or hand spade to cut 3 sides of a square, at least 3 inches deep, in the turf. Cuts can be of any size from 4 to 12 inches on a side. (Smaller cuts are easier to work with and heal quicker.) Flip back the turf and use a hand spade to loosen and remove soil from the soil/thatch region. Count the number of grubs per sample, and take samples at random locations throughout the area of concern (photo 9-22). The number and distance between samples varies depending upon the square footage being scouted. A grid or "X"-shaped sampling pattern provides the most thorough approach. For example, home lawns can be sampled in a grid-like fashion every 10 feet or at greater intervals. A closer sampling interval assesses the grub population more accurately. Average the number of grubs by the number of samples taken. Convert the area to square feet. The area sampled with a cup cutter is 0.1 square foot (photo 9-23). White grub infestations can be irregular from year to year. Higher grub populations should be expected during late summer and early fall of years with average or above average rainfall. Thresholds can be influenced by the turf condition. Weak, drought stressed turf cannot tolerate as many grubs per square foot as healthy turf. Also, the turf normally has a greater tolerance to a spring feeding because the environmental conditions favor turf growth. The one exception is the European chafer, which can be quite destructive in the spring.

White grub thresholds are influenced by the size of the grub and the condition of the turf. Five to 10 grubs per square foot can be used as a baseline threshold for Asiatic garden beetle, Japanese beetle and oriental beetle. If the turf is drought
stressed, or if the grubs are large like the European chafer, then the threshold decreases. Proper fertilization, sufficient soil moisture and/or small, newly hatched grubs can raise the threshold.

**TO TRAP OR NOT TO TRAP**

Insects release chemicals called pheromones that trigger a response in other insects of the same species. These chemical signals include sex pheromones and aggregation pheromones. Many pheromones are synthetically manufactured to use in conjunction with various traps to monitor for specific pests. There is a sex pheromone, mixed with a floral scent, available to attract Japanese beetle adults. When used with the appropriate trap, large quantities of beetles can be captured.

However, these traps have some drawbacks. First, they do not capture all the beetles in a given location, and thus will not have a major impact on the overall beetle population. Also, since this lure pulls in the actively feeding adults and not all are captured, there is increased feeding damage to surrounding vegetation. Finally, because of the mixture of sex pheromone (attractive to males) and the floral scent (attractive to both sexes), both males and females fly to the trap. Again, since all of the beetles are not captured, certain individuals mate and lay eggs in the surrounding turf. In areas with high populations of Japanese beetles, those traps could result in higher populations of larvae close to the trap’s locations. Thus, the traps can be used to monitor for adult emergence or for early detection of beetles in areas that are currently beetle-free, but should not be expected to remove all the beetles in a specific area.

**REFERENCES**


**RESOURCES**

**Evaluation**

National Turfgrass Evaluation Program (NTEP)
10300 Baltimore Ave., Bldg. 001, Rm. 245
Beltsville Agricultural Research Center – West
Beltsville, MD 20705
(301) 504-5125
[www.ntep.org](http://www.ntep.org)

**Suppliers of IPM-related Material**

Gemplers
100 Countryside Drive
P.O. Box 270
Belleville, WI 53508
(800) 382-8473
[www.gemplers.com](http://www.gemplers.com)

The Green Spot, Ltd.
93 Priest Road
Nottingham, NH 03290
(603) 942-8925

IPM Laboratories, Inc.
Main Street
Locke, NY 13092
(315) 497-2063
[www.ipmlabs.com](http://www.ipmlabs.com)

Great Lakes IPM
10220 Church Road, NE
Vestaburg, MI 48891
(517) 268-5693
[www.grealtakesipm.com](http://www.grealtakesipm.com)

**Disease Test Kits**

Hydros Environmental Diagnostic Inc.
230 Jones Road
Falmouth, MA 02540
(508) 540-2229
[www.hydros.cc](http://www.hydros.cc)

Neogen Corporation
620 Lesher Place
Lansing, MI 48912
(517) 372-9200
[www.neogen.com](http://www.neogen.com)
Chapter 10: Beneficial Organisms in the Turfgrass Environment

Timothy M. Abbey

The turfgrass environment, home to a number of pests, also contains many beneficial organisms. Care should be taken to preserve these parasites, pathogens and predators, so that they can assist with pest control. By ignoring the beneficials, and through the over-reliance on and misuse of chemical insecticides, a variety of pest management problems can increase. For example, many insects have developed resistance to certain pesticides; new pests have arisen to replace those successfully controlled; the effectiveness of natural control agents (predators, parasites and pathogens) has been reduced by pesticide misuse; and there is increased concern about pesticide safety and environmental quality. Thus, the role of beneficial organisms in turfgrass pest management should not be overlooked.

Two approaches to biological control can be used to maximize the impact of beneficial organisms on turfgrass pests. First, the homeowner or turf professional should become familiar with the identification and life cycle of the common beneficial organisms. If these predators and parasites can be recognized, then their population levels can be factored into the pest management decision-making process.

Second, if a particular pest is approaching damaging levels, and no natural enemies are present or are at too low a level to have an impact, then commercially available organisms may be of value. However, the process is not as easy as just ordering a product and releasing it. It is necessary to know what beneficial organism provides the best control under the environmental conditions present. Cultural practices can also impact biological control effectiveness.

A final consideration is that biological control normally does not reduce the pest population as quickly as a pesticide application. In order for the beneficials to provide long-term assistance, a small number of pests need to remain in the turf area.

NEMATODES

Nematodes are one interesting biological control organism that can be purchased commercially (photos 10-1 and 10-2). Though some species occur naturally in Connecticut soils, they usually occur at a level that is not sufficient for control of turfgrass insect pests. These parasites are microscopic, unsegmented round worms that live in the soil and, depending on the species, attack soil or thatch-dwelling insects. Currently, the 2 nematode families that contain the insect parasitic nematode species most useful for insect pest management are Steinernematidae and Heterorhabditidae. The commercially available beneficial nematodes include Steinernema carpocapsae, S. feltiae, Heterorhabditis bacteriophora and H. megidis.

The life cycle of beneficial nematodes consists of eggs, 4 larval stages and the adults. The third larval stage is the infective form of the nematode. Nematodes that can move through the soil search out susceptible hosts, such as white grubs and billbug larvae, by detecting excretory products and carbon dioxide. Other nematodes ambush their prey, such as cutworms or sod webworms, as the prey moves past. Juvenile nematodes enter the insect host through the mouth, anus or breathing holes (spiracles). Heterorhabditid nematodes can also pierce through the intersegments of the body wall. The juvenile form of Steinernematid nematodes carry Xenorhabdus sp. bacteria in their digestive system; Heterorhabditid nematodes carry Photorhabdus sp. bacteria. The bacteria are released into the insect host usually causing the grub to die within 1 to 3 days. However, since infection and mortality are temperature dependent, some infections won't result in mortality for weeks.

As the bacterial enzymes breakdown the internal structure of the insect, the Steinernematids develop into adult males and
females that mate within the insect's body cavity. Heterorhabditids produce their young as hermaphrodites. A hermaphroditic individual has the reproductive organs of both sexes.) As the nematodes grow, they feed inside the body on insect tissue broken down by the bacteria. After 1 to 3 generations, the insect's resources become depleted. At this point, the third juvenile stage nematodes exit the remains of the insect body (photo 10-3).

Parasitic nematodes have a number of favorable pest management characteristics. First, they have such a wide host range that they can be used successfully on numerous turfgrass pests. Second, nematodes usually kill their insect hosts within 48 hours. When compared to some standard insecticides, this is quite slow. However, during this time period the insect host does little if any feeding. Third, nematodes can be grown on artificial media allowing for mass commercial production. Fourth, the infective juvenile stage is durable. The nematodes can stay viable for months when stored at the proper temperature. They can survive 2 to 3 months at temperatures between 60°F and 80°F and 6 months when refrigerated at 37°F to 50°F. They can also tolerate being mixed with certain insecticides, herbicides and fertilizers. Check the nematode label for compatibility. Also, the infective juveniles can live for some time without nourishment as they search for a host. Finally, there is no evidence that parasitic nematodes or their symbiotic bacteria can develop in vertebrates. This makes nematodes a safe and environmentally friendly pest control option. The United States Environmental Protection Agency has ruled that nematodes are exempt from registration because they occur naturally and require no genetic modification by man.

Experiments have shown that parasitic nematodes can reduce the populations of several key turfgrass pests. Turf pests vulnerable to nematode attack include surface pests such as cutworm and sod webworm larvae; and the soil dwelling billbug larvae and some species of white grubs (photo 10-4). Nematodes can be used on these turf feeders as long as proper application procedures are followed and the environmental conditions are favorable.

It is important to select the proper nematode species for the targeted insect pest. Steinernema carpocapsae is most effective on surface feeders like cutworms and sod webworm larvae. Heterorhabditid nematodes prefer very moist soil and can penetrate as deep as 3 to 6 inches into the soil profile.

Though nematodes can be an effective and safe pest management option, there are limitations to their use. The first is related to their production and storage. It is difficult to synchronize the development of infective juveniles under laboratory conditions. Also, the nematodes must be shipped in the proper media and stored at the correct temperature to prevent premature death. Thus, it is a good practice to check the percent viability of a package of
nematodes before application. This can be done by placing a small amount of nematode-containing material in water, waiting a few minutes and then observing nematode activity under a microscope or hand lens (greater than 20X magnification is preferable). To make the whitish-colored nematodes more visible, use a dark background. Live nematodes are active and S-shaped. Dead nematodes do not move and are straight.

Also, to ensure that the nematodes are carrying the bacteria, an infectivity test should be conducted. Larvae of the wax moth, *Galleria melonella*, are placed into contact with the nematodes. The larvae are then monitored to determine their mortality. Individuals interested in testing their nematode shipments can contact the entomologists at the Connecticut Agricultural Experiment Station Valley Laboratory in Windsor, CT. The soil from the turf area can also be tested in the same manner to determine the presence of pre-existing nematodes.

In order to ensure maximum effectiveness, it is crucial to apply them at the optimum time and environmental conditions. For white grub management, nematodes should be applied from mid-August to mid-September (photo 10-5). The grubs are small at this time allowing for greater infection. Also, the soil temperature is warm, which favors greater nematode movement. The other possible time to use nematodes for grub control is in the following spring. However, the grubs are large and not as susceptible to infection. Also, most grub species do not return to the upper root zone where there is a greater chance that they will be found by searching nematodes. The cooler spring temperatures decrease nematode movement.

Application timing for the other turfgrass pests (bluegrass billbug larvae, sod webworm larvae) is during the summer when these pests are active. Nematode applications, especially during the middle of summer, are vulnerable to the following environmental conditions.

It is necessary to irrigate the target site both before and after application (photo 10-6). Soil moisture prevents desiccation and aids with movement. Direct sunlight, especially UV light, is extremely harmful. It makes the nematodes sterile and then kills them. Also, the best results are obtained when the relative humidity is high, ambient air temperature is neither extremely hot nor cold, and the soil temperature is between 55°F and 90°F. Furthermore, nematode effectiveness is influenced by other soil characteristics such as soil texture (soil type), pore size, aeration and soil chemistry. For example, nematodes would prefer soils with less clay and a pH around 7. All of these factors influence the chance for successful pest control. Nematodes often establish themselves after a release so reaplication of nematodes each year may not be necessary. (More information on insect parasitic nematodes, including wholesale and retail suppliers, can be found at [http://www2.oardc.ohio-state.edu/nematodes](http://www2.oardc.ohio-state.edu/nematodes))

**MILKY SPORE DISEASE**

Another commercially available beneficial is the pathogen *Paenibacillus popilliae* (formerly *Bacillus popilliae*), also known as milky spore disease. *Paenibacillus popilliae* is the oldest microbial product registered as an insecticide. The strain that is most familiar to turf professionals and homeowners is effective only against Japanese beetle grubs. The bacterial spores are placed by hand on the turf area, usually in a 4 by 4 foot grid pattern. A drop spreader can be used to make a thorough application of the granular formation over the entire turf area. The material should then be watered into the turf (photos 10-7, 10-8 and 10-8a). As grubs feed, they ingest the spores that then develop into bacteria. They move from the gut into
the grub’s circulatory system. The continued bacterial development turns the grub a noticeable white color; hence, the name milky spore disease. Infected grubs may survive for a month, but their level of root-feeding declines. Once the grub dies, the new spores enter the soil and can then infect other grubs.

The purpose for release of this product is to add to any naturally occurring *Paenibacillus popillae* and thus, establish a long-term management scheme for the Japanese beetle population in the area. The most effective application strategy is to apply the spores on a community-wide basis and not limit it to a few individual sites.

There are 4 major limitations encountered with milky spore disease. First, production of the spores is a costly, time-consuming process. Often, a high percentage of the spores produced are not viable (i.e. will not cause infection). Second, the disease does not become established, to any significant degree, in areas like Connecticut that do not have prolonged soil temperatures above 70°F during the grub life stage, or dense enough population of grubs to support continued infections. Third, since this organism requires an active larval population to ingest it, and over time move new spores across a turf area, it is not compatible with quick-acting chemical insecticides. Without grubs, the spores remain in limited areas throughout the lawn. This presents a difficult situation. Tolerance for grub presence may be extremely low, but without the grubs, any long-term suppression of the Japanese beetle population with milky spore will not occur. Finally, while many white grub infestations are a mix of beetle species, the commercial milky spore works only on Japanese beetle grubs.

In spite of these limitations, milky diseases (other than the commercially available strains) are common in Connecticut soil and often found in oriental beetle larvae. While this disease may not prevent some damage to turf in the long run, it may prevent major, multiple-year outbreaks.

**NATURALLY-Occurring DISEASES**

Even more important than the beneficiaries that can be purchased, are the ones that occupy the turf naturally. Though they may not always provide the level of control necessary, it is still important to learn the identification and life cycle of the most common biological control organisms.

Another disease commonly found in Connecticut infects only Japanese beetle larvae and was described by Connecticut Agricultural Experiment Station scientists. This disease, *Entoderma popillae*, appears as a whitish scabby patch on the cuticle of the Japanese beetle abdomen or thorax and can infect up to 90% of Japanese beetle larvae, killing them before they become adults. If a high incidence of disease is noted, then no other control measures would be warranted.

*Beauvaria bassiana* is a naturally-occurring fungus (that is also commercially available to licensed operators) which kills immature and adult stages of chinch bugs and the adults of bluegrass billbugs. *B. bassiana* becomes active during warm moist weather and can occur from May to September. Early detection of fungal outbreaks is difficult, but during periods of high relative humidity, infected insects become covered with white mycelium that later sporulates on the surface of the dead insect. These insects are quite distinct.

**Predatory insects**

Two species of **big-eyed bug**, *Geocoris bullatus* and *G. uliginosus*, are important predators of chinch bugs. The big-eyed bug is as small as a chinch bug, brown-to-black colored with brownish wings folded across its back. It is slightly stouter in shape than a chinch bug and has 2 “big-eyes” protruding from its head. If big-eyed bugs and chinch bugs are both present, insecticides may not be required. Their similar appearance shows why it is important to learn the proper identification of both the pest and beneficial insects. A major pest management error would be made if an abundant population of big-eyed bugs is mistaken for chinch bugs and then treated with an insecticide. Further monitoring can determine if the beneficiaries are having an impact.
Another common group of predatory insects are the **ground beetles**. The different species feed as both immatures and adults on such pests as chinch bugs, cutworms, sod webworms, grubs and various pest eggs. These beetles have a wide assortment of colors – from red to brown to black. Some species are very active during the day and are often misidentified as some type of pest insect. Other species are nocturnal and hide during the day.

**Rove beetles** feed on insects, such as sod webworm eggs and larvae, and on organic matter. They are brown to black insects with short front wings (elytra) that extend only halfway down the abdomen. Both the adults and larvae are active feeders.

**Ants** serve as a beneficial insect by feeding on pest eggs and small turf pests. However, depending on the species, ants can also be pests. Some species build mounds where the disrupted soil covers the turf. Their tunneling damages the roots and causes the soil to dry quicker. Some ant species can also bite or sting. Ants are often considered a pest because they are highly active and are easy to see as they forage for food. In some instances, their presence on sidewalks, driveways or in the home is undesirable.

Two families of **wasps**, Scoliidae and Tiphiidae, parasitize white grubs in the soil. Females hover over the turf area searching for areas with high grub densities. Scoliids are large, dark-colored wasps with yellow and orange abdominal markings. Tphiids are not as large as the Scoliids and have a yellow and black color pattern. These wasps are not common, and their impact may be restricted to small geographic areas. Other wasps in the family Vespidae can reduce populations of armyworms (photo 10-9).

The female **winsome fly** (*Istocheata aldrichi*), in the family Tachinidae, parasitizes adult female Japanese beetles. This fly is present in New England. The fly typically lays 1 to 4 distinct white eggs on the thorax, directly behind the head, of adult Japanese beetles (photo 10-10). The egg hatches in 24 hours and the maggot enters the beetle. The beetle dies within 5 to 6 days.

Other than the pest and beneficial insects, a wide variety of interesting insect life can be encountered in a lawn. Crickets, earwigs, fleas and many other insects are common in turfgrass areas. One example, the **cicada killer wasp** (*Sphecius speciosus*) is a very distinct wasp that attracts considerable attention around turf and flowerbeds during late...
summer. The male wasp is aggressive during the mating season and drives intruders out of his designated area (photo 10-11). The female digs a burrow (photo 10-12) into loose, well-drained soil where she takes a parasitized cicada that serves as food for a larva. Because of their size, buzzing activity and resemblance to the much smaller yellow jacket, they appear to be a potentially painful threat. Luckily, the males cannot sting, and the non-aggressive females only sting if handled.

**ENDOPHYTES**

Another beneficial organism, mentioned earlier in the turfgrass selection and the lawn establishment sections, is the endophytic fungus found in perennial ryegrass, tall fescue and fine-leaf fescue. The value of endophytic grasses again emphasizes the proper selection and installation of the correct grass species for each location. Through their use, not only are turf areas healthier, but the need for chemical insecticides is reduced or eliminated.

Endophytic fungi can be found in certain varieties of 3 turfgrasses: tall fescue (*Festuca arundinacea*); fine-leaf fescues (*Festuca sp.*); and perennial ryegrass (*Lolium perenne*). Kentucky bluegrass (*Poa pratensis*) is not naturally infected with an endophytic fungus. The fungi *Neotyphodium lolii* and *N. coenophialum* live inside the grass plant in a mutualistic relationship that provides benefits to both fungus and grass plant. These fungi do not produce external reproductive structures, but instead use the grass seed to propagate. The endophyte mycelium is present in the leaf blades, leaf sheaths, stem and crown and causes no interference with host cell function.

The fungus receives nutrition, long-term protection, improved dissemination through the grass seeds and overall improved survival. The benefits to the grass plant are where endophytes play a role in turfgrass IPM. Grasses that contain endophytes not only have increased resistance to chinch bugs, billbug larvae and turf-feeding caterpillars. They also have increased tolerance of environmental stresses through greater drought tolerance and nitrogen efficiency. This ability strengthens overall grass health during stressful conditions and enables it to withstand disease pressure. Endophytes may also promote turf growth, seed germination and seedling development.

The actual method of plant protection by the fungus appears to be a combination of antibiotics and feeding deterrence of insects. This is caused by the production of alkaloids by the endophyte. Production of these protective chemicals depends on the concentration of endophyte in the grass plant, the nutritional condition inside the grass plant and in the soil, and the sunlight, water and temperature of the surrounding environment.

Even though endophytic grasses can be an important factor in an IPM approach, they do have limitations. Endophytes provide no resistance to root feeding white grubs. The fungal mycelium and associated toxins do not enter the roots. However, endophytic grasses, especially tall fescue, may have indirect tolerance of grub damage because of their ability to withstand the drought-like stress caused by grub feeding. However, this benefit may be offset by reduced predation on white grub eggs and larvae. Predators may not be as common because of food limitations (i.e. no sod webworm eggs or larvae) so there is less overall feeding on any of the turf insect pests present. Care must be taken when selecting a cultivar of tall fescue, fine-leaf fescue or perennial ryegrass because certain ones do not have high levels of endophytic fungi and would not provide strong insect resistance. To maintain endophyte viability, seeds must be kept in a cool, dry location and used as soon as possible. Also, endophytes are toxic to grazing animals and should not be used if they are present.

**REFERENCES**


Chapter 11: Vertebrate Turfgrass Pests

Timothy M. Abbey

Besides the insect pests, some vertebrate animals also have the potential to destroy turfgrass. The following mammals and birds rip apart turf areas to feed on white grubs, sod webworm larvae or earthworms. However, if the prey populations are minimal, the damage from these animals should be of little concern.

Starlings (Sturnus vulgaris) and the common grackle (Quiscalus quiscula) form flocks that forage through turfgrass. If flocks are small, the turf actually benefits as insects are removed. However, large flocks can injure grass through vigorous pecking and scratching.

11-1: Damage from crows looking for white grubs.

The American crow (Corvus brachyrhynchos) can cause greater damage due to its larger size (photo 11-1).

Moles are probably the most frequent vertebrate pests homeowners encounter in the lawn. The eastern mole (Scalopus aquaticus) and the star-nosed mole (Condylura cristata) feed on earthworms and other invertebrates in the soil. Their tunneling pushes up ridges in the turf and forms soil mounds in certain locations where deeper tunnels are built. These areas can be hazardous to mowers and people. The tunneled grass often discolors and dies during dry weather. To prevent this from happening, depress and water this turf as soon as the tunnels are found. Moles are solitary creatures, but a substantial number can be found in one location if there is enough food. Most activity occurs at dusk and dawn.

Earthworms are the mole's primary food source, however a large white grub population promotes activity. If this is the case, controlling the white grub population can alleviate mole problems. Another indirect method is to construct soil barriers around the areas that require protection. Stone-filled or heavy clay soil should be incorporated to a depth of 2 feet with a one-foot width. This material is too difficult for moles to tunnel through. This approach can be limited by the size of the lawn and the severity of the mole infestation.

In the spring, flooding the tunnels with water can force adult moles to the surface and drown the young in the nest. This tactic requires work and precise detection. The eastern mole does not leave signs (molehills) that mark where deep tunnels are. You must look for the tunnel ridges, paying particular attention to straight tunnels. These are the feeding tunnels. These tunnels may connect or lead back to one central location that could be the den. To establish which tunnels are active (some are used only once), collapse a tunnel and then check back in a few hours or the next day to see if the ridge has been restored. Flooding an active tunnel that appears to run to a central point may force an adult to the surface where it can be destroyed.

The detection of active tunnels is also important for other types of direct control. Moles can be captured live and removed. Once an active tunnel has been located, dig in the soil at the bottom of the tunnel to a depth where a large container can be placed. The mouth of the container should be flush with the bottom of the tunnel. Cover the container and tunnel with a board so that the area is dark. Check the trap daily to look for captured moles that can be taken to another location and released.

Lethal traps are available that are very effective for mole management. Again, the location of active tunnels is the key.
Once these tunnels have been located, collapse a tunnel and place one of the commercially available traps in an excavated area of the tunnel. When the mole reaches this depressed tunnel and tries to raise it, the trap is triggered and kills the mole.

Though most people may not agree, the striped skunk (*Mephitis mephitis*) can actually serve as a beneficial animal. These animals are omnivores, feeding on both plants and animals. Part of their diet includes rodent and insect pests. Like the examples mentioned previously, skunks can become a nuisance when they rip apart turf to feed on earthworms, grubs and other insects. Raccoons (*Procyon lotor*) also dig through turf areas to feed on grubs. Thus, grub control is essential for reduction of turf damage caused by vertebrate pests.

**REFERENCES**


Chapter 12: Turfgrass Alternatives

Timothy M. Abbey

In some landscape locations, the conditions may not be suitable for establishment of the desired turfgrass. For example, a location may be too shaded, too wet or too dry. The first corrective measure is to select a turfgrass that can tolerate the conditions. If the site is too poor for successful turf establishment, there are a few other options.

Areas with excessive shade can be planted with a ground-cover such as English ivy (*Hedera helix*) (photo 12-1), Japanese spurge (*Pachysandra terminalis*) (photo 12-2) or common periwinkle (*Vinca minor*) (photo 12-3), though *ivy and vinca can become invasive*. Also, a shaded turf area can be managed as a beautiful, low input moss lawn. These plants provide a substitute for a poor turf stand.

Lawn sites that are exposed to excessive sun and drought conditions, such as southwest facing slopes, may be converted to sun-loving flowers. Perennial flowers require less fertilizer and water compared to a turf area. The mix could include black-eyed Susan (*Rudbeckia*) (photo 12-4), blue fescue (*Festuca cinerata*) (photo 12-5), butterfly weed (*Asclepias tuberosa*), tickseed (*Coreopsis sp.*) (photo 12-6), daylilies (*Hemerocallis*) (photo 12-7), purple coneflower (*Echinacea purpurea*) (photo 12-8) and Russian sage (*Perovskia atriplicifolia*) (photo 12-9), to name a few.

Another option is to reduce the amount of turf in the problem area by creating or expanding more formal ornamental gardens. There are numerous options to consider – annual flowers, herbaceous perennials, ornamental grasses, shrubs, trees or combinations. For a detailed list of trees, shrubs and vines suitable for demanding landscape situations in Connecticut, consult the following references for assistance with plant selection specific to southern New England.

REFERENCES

Health Management of Woody Ornamentals. University of Massachusetts Extension. (413) 545-2717.


University of Connecticut Plant Database: www.hort.uconn.edu/plants/
Appendix A

STARTING AN IPM PROGRAM

1. Develop a marketing plan to sell the program. Include positive impacts from previous accounts such as improved turf quality or improved pest management with fewer applications of chemical pesticides. Fully explain what an IPM program entails – scouting and decision-making versus regularly scheduled fertilizer and pesticide applications. A color brochure can be a useful tool for promotion of the business.

2. Train employees to make detailed observations and to use sound judgment when making decisions. Communicate clearly with the client after each visit.

3. For each account, identify the turfgrass(es) present and the key pests.

4. Try to visit each location every 2 weeks. This may be extremely difficult to do considering the number of accounts. If every 2 weeks is excessive, then try to scout once a month. Monitoring activities can be streamlined by focusing on specific pest problems for the time of year. Remember that a true IPM program provides scouting/decision-making instead of regularly scheduled pesticide applications.

5. Monitor the lawn areas by walking in an S-, W- or X-shaped pattern over the entire area with random stops to sample 1% to 10% of the area. Special attention should be paid to locations with a history of problems or with a high aesthetic value.

6. Monitoring Tools
   - 10 to 20 X hand lens
   - Clipboard to hold scouting forms and other information
   - Traps, such as pitfall traps or pheromone traps, where applicable
   - pH meter for quick soil tests

7. Basic Equipment
   - Shovel and/or cupcutter
   - Knife (pruners for landscape ornamentals)
   - Plastic sample bags
   - Sample vials with alcohol
   - Cooler for samples
   - Waterproof marker
   - Flagging tape, colored flags or paint
   - Bucket, soap and water to search for chinch bugs and/or sod webworm larvae
   - Copies of all chemical pesticide labels and corresponding MSDS sheets

8. Additional Equipment
   - Field microscope
   - Camera with macro lens to document problems
   - Growing degree day meter

Appendix B

TIPS ON HOW TO HIRE A LAWN CARE SERVICE

Selecting a Lawn Service

1. What is the estimated price? Get several estimates, but remember, the least expensive service is not necessarily the best.

2. Check the cost. You may be able to do it yourself more cheaply if you want to. You are paying for the convenience of having the lawn treated professionally, and for the expertise of the personnel responsible.

3. What qualifications do the lawn care professionals have? Some companies only hire people with advanced degrees in the field.

4. Does your state require that the applicators or the company be licensed? If so, have you checked to make sure your company fulfills state licensing requirements?

5. Is the company fully insured?

6. Are the lawn care professionals able to answer all of your questions?

7. Is the company a member of a trade association with a consumer-oriented code of ethics? (Such as the Connecticut Grounds Keepers Association or the Professional Lawn Care Association of America.)

8. Do they have references from other customers?

9. Have you checked with the Better Business Bureau where the company is located for the report?

10. Has the company provided you with a written agreement or simply contacted you by telephone? If you accept service over the phone, did you get a follow-up call to confirm details?

11. Will the service be automatically renewed year to year? Will the company confirm this in writing or by the telephone each winter?

12. Do you know how to cancel the agreement?

13. How will you know whether or not products need to be watered into the soil? Will the company give you other suggestions on how to improve the effectiveness of their service? Will the company instruct you by letter or phone?
14. Can the company explain what each pesticide application is targeted for?

15. As a precaution, keep yourself, your family and pets off the lawn during an application and until the turf is dry.

16. Understand the fertility program. How many pounds of nitrogen will they apply during the year and when? How about phosphorus and potassium? Unless soil tests indicate otherwise, the nitrogen-phosphorus-potassium (N-P_2O_5-K_2O) ratio should be around 4:1:2. Excessively high nitrogen with low phosphorus and potassium may make a dark green lawn, but it doesn’t make a very healthy lawn and problems will probably appear in several years.

17. Understand the chemicals that will be used. What will be used for broadleaf weed control? How about insect and disease control? Who will diagnose problems and how will they be verified? What will be used for grassy weed control? What will be done should the customer or neighbors object to the chemicals? What if shrubs or flowers should be damaged from herbicides, how will responsibility for damage be handled or proven?

18. If you are looking at a company that uses “organic” methods, find out what they exactly mean by organic.

19. Determine how flexible the program is. Not all lawns require the same level of management. Is the company willing to change their standard program according to your specifications? Will they delay an application until more suitable weather if you request it?

20. Find out who is in charge. With whom will you communicate regarding problems? Who will assess problems? Who will apply the treatments? Who will check on quality control? What training have the employees had?

21. Ask other customers about the company. Do your friends and neighbors using that company feel it is responsive to their needs?

22. Understand the guarantee. Make sure you understand every provision in the written guarantee. Will they refund all your money or just the last application if you are not satisfied? What would they require as proof that they damaged your lawn or shrubs?

23. Realize that you still have to be highly involved in caring for your lawn if you want it to be healthy.


**Appendix C**

**TURFGRASS FERTILIZER GRADES AND RATIOS**

Fertilizers are available in many different grades and ratios. Turfgrass fertilizers are formulated to provide primarily N, P and K, or varying combinations of these 3 nutrients. The fertilizer grade is the minimum guaranteed analysis of the nutrients and by law, must be listed on the fertilizer bag. The 3 numbers on a fertilizer bag indicate the grade. The numbers represent the percentage by weight of elemental N, available phosphate (P_2O_5) and water soluble potash (K_2O). For example, a fertilizer bag with the grade of 20-5-10 contains 20% nitrogen, 5% phosphate and 10% water-soluble potash by weight. This is called a complete fertilizer because all 3 numbers representing N, P and K are present.

The ratio of a fertilizer is the relative ratio between the 3 nutrients that form the grade. Therefore, a 20-5-10 fertilizer has a ratio of 4:1:2. The fertilizer ratio can be determined by dividing each number of the fertilizer grade by the smallest number of the grade. If a recommendation calls for use of a fertilizer ratio of 2:1:1, then the following fertilizer grades could be used: 20-10-10, 10-5-5 or 14-7-7.

Using the fertilizer grade allows you to calculate how much N, P and K are applied to the turf by any amount of fertilizer applied. For example, if a 50-pound bag of 30-4-4 fertilizer is applied to the turf, the actual amount of N, P and K applied would be determined by:

First, finding the decimal forms of the grade percentages by dividing the grade by 100:

\[
\begin{align*}
30\% \text{ N} &= 0.30 \\
4\% \text{ P}_2\text{O}_5 &= 0.04 \\
4\% \text{ K}_2\text{O} &= 0.04
\end{align*}
\]

Then, multiply the decimal form of the grade by the amount of fertilizer applied:

\[
\begin{align*}
50 \text{ lb} \times 0.30 \text{ N} &= 15 \text{ lb N} \\
50 \text{ lb} \times 0.04 \text{ P}_2\text{O}_5 &= 2 \text{ lb P}_2\text{O}_5 \\
50 \text{ lb} \times 0.04 \text{ K}_2\text{O} &= 2 \text{ lb K}_2\text{O}
\end{align*}
\]

A turf type fertilizer is usually defined as a complete fertilizer having an approximate ratio of 2:1:1 or 3:1:2 or 4:1:2 and containing a minimum of 10% N with 30% or more of the total N as water insoluble or controlled-release N. For the slow- or controlled-release fertilizer forms, N availability is separated into 3 percentages based on the water solubility of the N:

- CWSN – cold water soluble N, the % of N that is immediately released.
- CWIN – cold water insoluble N, the % of N that is slowly released; sometimes referred to as HWSN (hot water soluble N).
- HWIN – hot water insoluble N, the % of N that is very slowly released.
The value of water insoluble N (WIN) is a measure of the slow-release properties of a N fertilizer. In addition to this measure, the Activity Index (AI) of a slow-release fertilizer is frequently used to categorize the slow-release properties and activity. The AI is the percentage of CWIN that is soluble in hot water (HWSN). It is calculated as:

\[
\frac{(CWIN - HW\overline{W}N)}{CWIN} \times 100\% = \text{measure of relative solubility, or the } \% \text{ CWIN that is HWSN}
\]

A fertilizer with a high WIN or AI value indicates that the N will be slowly released with time. A fertilizer containing at least 30 to 40% WIN gives a better distribution of turf growth and quality during the season than a form that is nearly all fast-release N.

If a fertilizer contains a slow-release N source, it is listed on the fertilizer label. The amount of the total N percentage that is WIN can be determined by using the following calculation:

\[
\frac{\%\text{WIN}}{\%\text{ total in fertilizer}} \times 100\% = \text{% of total N that is WIN or slowly available}
\]

For example, if the fertilizer label reads: Total Nitrogen 22%

8% Water Insoluble Nitrogen (WIN), then:

\[
\frac{8}{22} \times 100\% = 36\% \text{ of total N is WIN or slowly available}
\]

If WIN is not listed on the fertilizer label, then it should be assumed that all N is water soluble or fast-release, unless sulfur-coated urea is used. Sulfur-coated urea does provide slow-release N, but the fertilizer label does not list it as WIN; it is usually listed as a controlled-release N. If a fertilizer does contain sulfur-coated urea or polymer-coated urea, include that portion as WIN when determining the amount of N that is slow release.

**Appendix D**

**HOW TO CALIBRATE A FERTILIZER SPREADER**

**Procedure:**

1. Measure the spreader application width.
   
   For drop spreaders, the measurement is straightforward — measure from end to end of the fertilizer box. For rotary spreaders, however, you need to determine the width of the “throw” from the fertilizer hopper. Place some type of marker on the lawn (rope, rakes, long-handled shovels, shallow boxes, etc.) at 3, 4, 5 and 6 feet from the center line of the spreader. You need 8 markers; 2 for each side. Place a small amount of fertilizer in the hopper of the rotary spreader. Mark the center line and walk at normal walking speed while pushing the spreader through the marked area. The marked area should be at least 10 feet from your starting point. Carefully observe where the fertilizer granules fall relative to the markers. You should be able to estimate the width of spread using this approach.

2. Select an area of lawn suitable to calibrate the spreader. Calibrate in a level area that is not highly visible and do not calibrate in the same spot repeatedly. To avoid contaminating water, do not calibrate on hard driveway surfaces; or near ponds, streams, lakes and storm drains. Although not recommended, if you choose to calibrate on hard surfaces such as a driveway, sweep up the spent fertilizer so that it does not run off with water. Measure off a 50-foot run and mark the start and finish points.

3. Make sure the fertilizer hopper is closed and fill the spreader with a preweighed amount of fertilizer (5 pounds should be sufficient). Add enough fertilizer to cover the bottom moving parts of the hopper.

4. The initial setting for the fertilizer spreader can be based on information available on the fertilizer bag, spreader manual, or if none is available then begin with a medium setting and adjust accordingly after each calibration trial.

5. Begin walking approximately 10 feet before the starting line, and open the spreader hopper as you pass the starting line. Continue across the 50-foot distance at your normal walking speed. Close the hopper on the spreader as you pass over the finish line.

6. Remove the remaining fertilizer in the spreader and weigh this amount.

7. Subtract the amount of fertilizer left in the spreader from the initial amount added. This gives the amount of fertilizer applied based on the width of your spreader over a 50-foot distance.

8. Calculate the square footage of the area covered in the calibration trial. This is simply calculated by multiplying the width of your spreader times the 50-foot length.
For example, if your rotary spreader’s throw is 5 feet wide, then your calibration area is 250 ft² (5 ft x 50 ft = 250 ft²).

9. Calculate the spreader rate (how much fertilizer applied per 1000 ft²) by using the following formula:

To solve for #9, divide #7 by #8 and then multiply by 1000.

Example: A 5-foot wide rotary spreader at the medium setting applies 1.5 lb of a 30-4-4 fertilizer over a 50-foot run. How much fertilizer is applied over 1000 ft²?

10. Compare the amount applied in the calibration trial with the target application rate found in Table 1 on the next page. The target application rate is based on soil test recommendations. Adjust the spreader setting to deliver more or less material if necessary. Repeat steps 3 to 9 until the target rate is achieved. Once the target rate is achieved, repeat again to make sure the calibration is steady.

For the example in #9, the calibration amount was 6 lb of 30-4-4 per 1000 ft². For a fertilizer with a grade of 30% N, the calibration amount is almost double that needed (3.3 lb). Therefore, you need to select a lower setting and recalibrate.

11. Fill spreader with fertilizer. Begin fertilization by spreading around the perimeter of the lawn. Then spread back and forth across the lawn at intervals based on the width of your spreader. If you fertilize in the morning, you should be able to see the wheel tracks of the fertilizer spreader or your footprints on the lawn. If you can’t see the wheel marks or your footprints after completing a fertilizer pass, pace off the distance of the fertilizer spread width and line up with an object on the opposite side of the yard— a fence post or a tree for example, and spread toward the object.

Exact amounts of fertilizer per 1000 ft² to equal 1 lb of N per 1000 ft² for fertilizers with a N grade from 1 to 36%.

**Spreading Modification for Rotary Spreaders**

Recent research has indicated that rotary spreaders do not always give an even distribution of fertilizer over the width of their throw—more fertilizer is applied nearer the center line of the hopper and less is applied away from the center line. Because of this, striping of the lawn may occur because different amounts of N are applied over the width of the spreader throw. To guard against this, it is recommended that you calibrate your spreader to half the recommended rate, then double spread the fertilizer by overlapping your spreading runs. This is accomplished by spreading at intervals of half the spreader throw width instead of the full width. By doing this, a more even distribution of fertilizer is applied. Table 2 on the next page gives amounts for 0.5 lb of N per 1000 ft². Although the calibration rate is 0.5 lb of N per 1000 ft², the recommended rate of 1 lb N per 1000 ft² will be supplied because you double spread the fertilizer over the lawn area.

Approximate amount of fertilizer per 1000 ft² to equal 0.5 lb of N per 1000 ft² in the calibration area. This calibrated rate supplies 1 lb of N per 1000 ft² because you double spread the fertilizer on the lawn.
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