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FERTILIZING LAWNS

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Healthy lawns depend on many factors including adequate water for cell enlargement and evaporative cooling, sunlight and carbon dioxide for energy production, and oxygen for respiration. Lawn growth also depends on nutrients or essential elements absorbed by roots from the soil. When natural soil processes do not provide adequate supplies of these essential elements, fertilizer can be applied to maintain optimum turfgrass growth. The purpose of fertilizing a lawn is to add the necessary nutrients in the required amounts and at the proper time to achieve desirable lawn qualities and healthy turfgrass plants. This publication should help to develop a fertilizer program to promote a healthy lawn.

Essential Elements

At least seventeen elements are required by plants for proper growth (table 1). Although each has different functions in plants and is required in differing amounts, a deficiency of any one can limit plant growth. Fortunately, most of the elements are supplied to turfgrass plants by natural soil processes. Three elements—**nitrogen (N), phosphorus (P),** and **potassium (K)**—are considered primary macronutrients because they are often required in larger quantities than are made available through natural soil processes. Deficiencies of the other elements are relatively rare and are generally associated with unusual soil conditions such as extremely sandy, acid, or alkaline soil.

Table 1. Elements essential to plant growth and their sources*

Used in relatively large amounts		Used in relatively small amounts
Mostly from air and water	From soil solids	From soil solids
Carbon	Nitrogen	Iron
Hydrogen	Phosphorus	Manganese
Oxygen	Potassium	Boron
	Sulfur	Molybdenum
	Calcium	Copper
	Magnesium	Zinc
		Chlorine
		Cobalt

*From N.C. Brady. 1984. *The Nature and Properties of Soils (9th Edition).*

Nitrogen

Adequate nitrogen produces vigorous growth and green color in turfgrass plants. Either too little or too much nitrogen can cause problems. Too little available nitrogen leads to slow growth, increased chance of some diseases, yellowing of plants, and thin turf. Too much nitrogen leads to excessive shoot and leaf growth, reduced root growth, low carbohydrate reserves, poor tolerance of environmental stresses, and increased susceptibility to some diseases.

Most nitrogen in the soil is present as part of organic matter and becomes available for use by plants as the organic matter is decomposed by soil micro-organisms. Decomposition of lawn clippings, plant roots, and other organic materials also provide nitrogen for use by plants. The amount of nitrogen provided by these natural soil processes is generally not adequate to maintain the vigorous growth desired in most lawns throughout the growing season; consequently, supplemental additions of nitrogen-containing fertilizer are usually required.

Before the nitrogen in organic matter can be taken up by plant roots, the organic matter must be broken down so that nitrogen is in the form of ammonium (NH_4^+) or nitrate (NO_3^-) ions. In most soils the ammonium form is quickly converted to the nitrate form. This nitrate form is not tightly held on the soil particles and is soluble in soil water. Consequently, in sandy soils with excessive rain or watering, nitrate can move with the water to depths below the root zone. In clay soils with excessive rain, nitrate can be leached below the root zone or converted to a gas and lost to the atmosphere.

Some nitrogen fertilizers are in forms that are available to turfgrass plants soon after application. These are called **quick-release** or **soluble** forms of nitrogen. Ammonium nitrate, ammonium sulfate, and urea are quick-release forms of nitrogen commonly used in lawn fertilizers (table 2). Fertilizers containing these quick-release forms of nitrogen produce a rapid response in turfgrass growth and color. They are also less expensive than slow-release forms of nitrogen (table 3).

Table 2. Typical nitrogen fertilizers used on lawns and turfgrass areas

Quick-release
Ammonium nitrate
Ammonium sulfate
Urea
Slow-release
IBDU (isobutylidene diurea)
Sulfur-coated urea
Ureaformaldehyde (such as Nitroform)
Natural organics (such as Milorganite)

Slow-release forms of nitrogen depend on soil processes to gradually break down the fertilizer particles and release nitrogen for use by plants. When properly applied, losses of nitrogen through leaching are usually minimized. Because different types of slow-release nitrogen have different characteristics and rely on different soil processes for release, the length of time during which one application will release nitrogen varies dramatically with the type of fertilizer, soil temper-

ature and moisture, and activity of soil micro-organisms. When compared to quick-release forms of nitrogen, the slow-release forms of nitrogen last longer, can be applied at higher rates, and have a lower leaf burn potential (table 3). Slow-release fertilizers are particularly beneficial on sandy soils.

Table 3. Advantages and disadvantages of using quick-release forms of nitrogen as compared to slow-release nitrogen

Advantages
* Nitrogen is available to plants immediately.
* Plant response is rapid.
* Less expensive.
Disadvantages
* Higher leaf burn potential.
* Higher potential for excessive surge of growth.
* Response to fertilizer lasts a shorter period of time.
* More frequent, lighter applications required.

Phosphorus

Phosphorus is important in stimulating early root growth and promoting early plant vigor. Phosphorus moves very little in the soil with most of it being bound tightly to soil particles. Soils naturally high in phosphorus are apt to provide sufficient phosphorus for vigorous lawn growth for many years without adding phosphorus in fertilizers.

There are three reasons why a phosphorus-deficient soil should be corrected prior to seeding. First, since phosphorus moves very little in the soil, it is desirable to mix the phosphorus throughout the root zone. This is relatively easy prior to seeding but more difficult after establishment. Second, seedling plants, with newly developing root systems, are most likely to be affected by lack of phosphorus. Third, mixing phosphorus into the soil (rather than applying it to the surface) reduces the chance for phosphorus to move into lakes and streams. Fully developed turfgrass root systems can absorb phosphorus from a much larger volume of soil, reducing plant deficiencies.

A soil testing laboratory can determine the current level of phosphorus in a particular soil. This inexpensive procedure is the best way to determine accurately the phosphorus requirements of a lawn.

Potassium

Potassium is important in the synthesis of some plant components and in the regulation of many physiological processes. Potassium deficiencies in lawns have led to increased incidence of turfgrass diseases and reduced tolerance to environmental stress.

Potassium is held on the surfaces of soil particles and moves little in most soils; however, it can gradually move out of the root zone in very sandy soils. Where soils are high in native potassium, supplemental potassium fertilization may be unnecessary; however, where soils are low in native potassium, supplemental applications are very important. Soil tests are essential to determine the potassium level of a soil and to develop a potassium fertility program.

Other Essential Elements

Adequate levels of the other essential elements are usually present in Minnesota lawns. Where deficiencies occur, they are usually associated with extremely sandy, highly acid, or highly alkaline soils. Where a deficiency is suspected, rely on soil test and advice from county extension agents as to the traits of soils in your area. For most lawns, attention to nitrogen, phosphorus, and potassium is all that is required.

Soil Tests

Soil tests are necessary to establish the proper lawn fertility program for a specific site. Soil tests can be obtained by submitting a soil sample to private soil fertility testing laboratories or to the University of Minnesota Soil Testing Laboratory. Informational sheets and materials can be obtained through your county extension office.

The proper ratio of nitrogen, phosphorus, and potassium to apply to a lawn can only be determined by soil testing. Since nitrogen can move rapidly out of the root zone with percolating water, soil tests for available nitrogen are not very meaningful and are generally not performed. Phosphorus and potassium move little in the soil and consequently soil tests will be valid for several years. The most important soil test is the first one so that you can establish the base levels of P and K in the soil. Subsequent sampling may not be necessary for many years if phosphorus and potassium levels are adequate.

The label on lawn fertilizer bags lists the percentages of the three primary nutrients as a series of three numbers called the **fertilizer grade**. As an example, a common lawn fertilizer grade is 23-3-6. In this case the fertilizer contains 23% nitrogen, phosphorus equivalent to 3% P_2O_5, and potassium equivalent to 6% K_2O.

One fertilizer grade is not best for all soils, since native soil phosphorus and potassium levels determine needs. If a soil is already high in phosphorus and potassium, a fertilizer with a grade of 34-0-0 or 46-0-0 would be sufficient, while a soil with low phosphorus or potassium would require additions of fertilizer containing phosphorus or potassium such as 20-5-10 or 20-4-16.

The University of Minnesota Extension Service has developed a computer program, TURFGRASS (AG-CS-2539), available through your county extension office, to help determine the most appropriate fertilizer for a given lawn situation. It also performs a suitability and a cost analysis of particular lawn fertilizers from user-supplied label information.

Lawn Fertilizer Application

The amount of nutrients required by a lawn or turfgrass area depends on the type of grass plants and the management practices (how much care you decide to give the lawn balanced with demands of the grass variety). A vigorously growing, watered lawn from which the clippings are removed requires more added nutrients than a lawn that is not watered during the summer and where clippings are left on the lawn. Consequently, in developing a lawn fertilizer program, it is appropriate to divide lawns into high and low maintenance groups based on management practices.

High-maintenance lawns are characterized by vigorously growing plants such as improved Kentucky bluegrass and improved, turf-type perennial ryegrass varieties. For best results these lawns are watered during the summer to maintain green growth. Clippings may or may not be removed. Usually there is no need to remove the clippings, in fact, clippings left on the lawn gradually decompose and reduce the need for fertilizer by about 1 lb N/1000 ft^2 per year. A vigorously growing lawn may develop a thatch layer and require occasional aerifying or vertical mowing to control thatch. High maintenance does not mean excessive maintenance. High maintenance is that required by many of our high quality lawns.

The fertilizer schedule for a high-maintenance lawn should consist of 3 to 4 pounds of nitrogen per 1,000 square feet of lawn area each year. If quick-release nitrogen sources are to be used, 3 to 5 applications should be made according to the schedule in table 4. The amount of phosphorus and potas-

sium required for the lawn is determined by a soil test. Tables 5 and 6 give recommended amounts based on a test at the University of Minnesota Soil Testing Laboratory.

Low-maintenance lawns typically contain plants such as creeping red fescue, chewings fescue, hard fescue, or some of the common types of Kentucky bluegrass which grow and spread more slowly than those found in high-maintenance lawns. These low-maintenance lawns do not commonly receive watering (other than rainfall) during the summer months and grass growth is minimal during hot, dry periods. Clippings are usually left on the lawns.

A low-maintenance lawn will typically require only 1 to 2 pounds of nitrogen per 1,000 square feet of lawn area per year. If clippings are returned to the lawn, the 1-pound rate is usually sufficient. Table 4 suggests how to schedule these applications. Phosphorus and potassium requirements for high and low-maintenance lawns should be determined from soil tests. Tables 5 and 6 are applicable to low- as well as high-maintenance lawns.

Table 4. Annual nitrogen requirements and application timing for lawns

Maintenance practices	Nitrogen (N) to apply	Timing of applications*
	lbs. N/1000 ft^2	
High maintenance lawn		
(Irrigation, clippings removed)	4	Aug., Sept., Oct.-Nov., May-June
(Irrigation, clippings not removed)	3	Aug., Oct.-Nov., May-June
Low maintenance lawn		
(No irrigation, clippings removed)	2	Aug., Oct.-Nov.
(No irrigation, clippings not removed)	1	Sept.

*Assuming 1 lb N/1000 ft^2 of quickly available nitrogen is applied at each application.

Table 5. Annual phosphorus requirements for lawns based on soil test results from the University of Minnesota Soil Testing Laboratory

Phosphorus soil test level	Phosphate to apply
lb P/acre	lb P_2O_5/1000 ft^2
0-10	2.0
11-20	1.0
21-50	0.5
>50	0.0

Table 6. Annual potassium requirements for lawns based on soil test results from the University of Minnesota Soil Testing Laboratory

Potassium soil test level	Potash to apply	
	High maintenance lawn with clippings removed	Low maintenance lawn with clippings remaining
lb K/acre	lb K_2O/1000 ft^2	
0-100	3.0	2.0
101-200	2.0	1.0
201-300	1.0	0.5
>300	0.0	0.0

Rate for a Single Application

The release characteristics of a fertilizer and its burn potential determine the amount that can be applied in a single application. Fertilizers with quick-release sources of nitrogen or potassium can burn the plants if applied at high rates. In addition, applying too much nitrogen in one application is inefficient since the nitrogen not used by the plant can leach through the soil and out of the root zone. Consequently, quick-release forms of nitrogen should always be applied at a rate of 1 lb N/1000 ft^2 or less in any one application. Since slow-release nitrogen is released gradually over a longer period of time, higher rates can be applied to the turf. Generally, however, rates higher than 2 lbs N/1000 ft^2 in a single application are not recommended even when slow-release fertilizers are used.

The area to be covered by a bag of fertilizer using a desired rate of nitrogen application rate can be determined from the information on the bag.

$$\frac{\text{weight of bag} \times \text{N in fertilizer (fractional basis)}}{\text{desired rate of application}} = \text{area to be covered by fertilizer in the bag}$$

For example, if you want to apply fertilizer at a rate of 1 lb N/1000 ft^2 and you have a 20-pound bag of a fertilizer having a grade of 23-3-6 (the fertilizer is 23% N), then

$$\frac{20 \text{ lb} \times .23}{1 \text{ lb N}/1000 \text{ ft}^2} = 4600 \text{ ft}^2$$

the fertilizer should be used to cover 4600 square feet of lawn area. If the lawn area is less than 4600 ft^2, then only a portion of the bag is needed to supply 1 lb N/1000 ft^2. If your lawn area is 2500 ft^2, then 11 pounds of fertilizer should be applied.

$$20 \frac{\text{lbs}}{\text{bag}} \times \frac{2500 \text{ ft}^2}{4600 \text{ ft}^2/\text{bag}} = 11 \text{ lbs}$$

Timing

Late summer and fall are the principal times of year to fertilize lawns (table 4). This is contrary to the traditional springtime application of most lawn fertilizer. Some advantages of fall rather than early spring applications are shown in table 7. Early spring applications of nitrogen cause a surge of top growth in the plants which makes the lawn look nice in the spring but depletes the plants' energy reserves. Consequently, when summer stress periods occur, plants are weaker and less able to survive. By applying fertilizer in late October or early November, when top growth is minimal but when soil temperatures are still warm enough for the nitrogen absorption, plants resume growth and green-up early the following spring without the excessive shoot growth associated with early spring nitrogen applications.

Table 7. Benefits from applying lawn fertilizers in fall rather than early spring

* Lengthened period of green in the fall.
* Earlier green-up in the spring without stimulating excessive shoot growth.
* Carbohydrate reserves (a measure of the energy stored in the plant and available for growth) remain higher during the spring and summer period.
* Reduced incidence of summer diseases.

Environmental Conditions

When fertilizing lawns, particularly with quick-release nutrients, it is important to consider the weather and turfgrass conditions to achieve maximum effectiveness of the applied fertilizer. Ideal conditions include a cool day with a good rain-

fall or watering immediately following the fertilizer application to wash the fertilizer off the leaves and into the soil. As the temperature increases, the potential for damaging the leaves through fertilizer burn increases; consequently, care must be taken by applying a lower rate of fertilizer, using slow-release forms, or washing fertilizer off the leaves immediately after application. Unless absolutely essential, fertilizer application using quick-release nutrients should be avoided when temperatures are greater than 85° F.

Spreader Use and Calibration

Many fertilizer spreaders are available and make fertilizer application easy. Two types of spreaders for granular materials are available: drop and rotary spreaders. Drop spreaders distribute the fertilizer directly below the hopper in a well-defined pattern. Rotary spreaders throw the fertilizer material out beyond the spreader in several directions and are satisfactory for most lawns. Although rotary spreaders give a less precise distribution, they are much faster and are less apt to leave a striped pattern on the lawn where areas were missed. With either type of spreader it is a good practice to fertilize one-half the desired application rate in one direction, then the second-half perpendicular to that direction.

Fertilizer spreaders will apply different materials at different rates. Ideally, you should calibrate your spreader for your pace and the fertilizer used. To calibrate a spreader with a given fertilizer, adjust the spreader setting to a selected level, weigh out a known amount of fertilizer, spread that amount of fertilizer and measure the ground area covered in the process. It may be convenient to do this on a sheet of plastic. To calibrate according to the pounds of nitrogen/1000 ft^2, make the following calculation:

$$\frac{\text{lbs. of fertilizer}}{\text{ft}^2 \text{ of area covered}} \times \text{N in fertilizer (fractional bases)} = \text{lbs. N/ft}^2$$

$$\text{then} \quad \text{lb N/ft}^2 \times 1000 = \text{lb N/1000 ft}^2$$

For example, if the spreader is set at 8, you find 0.6 pounds of fertilizer covers an area of 100 ft^2, and the fertilizer has a grade of 23-3-3 (the fertilizer is 23% N), then

$$\frac{0.6 \text{ lbs of fertilizer}}{100 \text{ ft}^2 \text{ area}} \times 0.23 \frac{\text{lb N}}{\text{lb fertilizer}} = 0.0014 \text{ lb N/ft}^2$$

$$0.0014 \frac{\text{lb N}}{\text{ft}^2} \times 1000 = 1.4 \text{ lb N/1000 ft}^2$$

This spreader at a setting of 8 applies this fertilizer at the rate of 1.4 lb N/1000 ft^2. Next, make the same measurement at several spreader settings. Then develop a chart for that fertilizer that gives the rate of nitrogen application at various spreader settings and you can choose the setting for any desired application rate. Realize that different fertilizers would have different calibration curves. Manufacturers of lawn fertilizers often recommend a setting for specific fertilizer spreaders.

Liquid vs. Dry Fertilizers

It is quite common to apply lawn fertilizer dissolved in a liquid rather than as a granular material. It probably makes little difference to the plants whether the nutrients are applied in liquid or dry form if the fertilizer is washed off the leaves and into the soil soon after application.

Fertilizer-Herbicide Combinations

Lawn fertilizers are commonly mixed with herbicides to reduce the labor involved in lawn maintenance. Care should be used in applying these products. Fertilizer application should be a regular lawn maintenance practice, but herbicides should be used only when specific weed problems occur. For effective weed control, herbicides are used at specific times during the year, sometimes differing for various weeds. The times of herbicide effectiveness may not be the optimum time of year for fertilizer application. An additional problem with combination products is that fertilizers should be watered-in, following application, for maximum effectiveness and low burn potential, while many herbicides need to remain on the plant leaves for effective weed control. Consequently, by using fertilizer-herbicide combination products you often compromise the effectiveness of one or both products from a timing or application standpoint, or both. Certainly fertilizer-herbicide combinations should never be used when the herbicide would be ineffective or unnecessary.

Lawn Fertilization and Environmental Problems

There has been concern in some communities that the use of lawn fertilizers contributes to lake and groundwater pollution problems. Proper fertilization should not cause either the groundwater or lakes pollution; however, misapplication such as excessive nitrogen in a single application, leaving fertilizer on sidewalks or streets to be washed into storm sewers can add to environmental problems. For a more complete discussion, see the Minnesota Extension Service fact sheet entitled "Preventing Pollution Problems from Lawn and Garden Fertilizers" (AG-FS-2923).

Summary Tips on Fertilizing Lawns

1. Obtain a soil test to determine the proper grade fertilizer to use (%N-%P_2O_5-%K_2O).
2. Apply most of the fertilizer in fall rather than spring.
3. Apply no more than 1 lb N/1000 ft^2 in a single application if quick-release fertilizers are used.
4. For each application spread the fertilizer in two directions.
5. Use a rotary spreader for speed and convenience.
6. Water the lawn immediately after fertilizing.

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More information on lawn care is available through the University of Minnesota Extension Service, including the following publications:

The Home Lawn (AG-BU-0488) $2
Preventing Pollution Problems from Lawn and Garden Fertilizers (AG-FS-2923) 20¢
Watering Lawns and Other Turf (AG-FS-2364) 20¢
Controlling Lawn and Turf Insects (AG-F0-1008) 50¢
Patch Diseases of Lawns (AG-FS-3034) 20¢
Weed Control in Lawns and Other Turf (AG-FS-1137) 20¢
Thatch Control in Lawns and Turf (AG-FS-1123) 20¢
Add 6 percent state sales tax to prices given.