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TABLE 1
Growth Regulators Available for Turf

Generic Name	Trade Name	Manufacturer	Vegetative Suppression	Seedhead Suppression	Root Absorbed	Foliar Absorbed	Broadleaf Weed Suppression	Restriction of Roots & Rhizomes	Phytotoxic[a]
Maleic Hydrazide	Several	Uniroyal Chemical	X	X		X		X	moderate-severe
Mefluidide	Embark	3M Corporation	X	X	Some	X	Some		low-moderate
Flurprimidol	Cutless	Elanco Corp.	X		X	X			low-moderate
Amidochlor	Limit	Monsanto Corporation	X	X	X				low-moderate
EPTC	Short-Stop	Stauffer Company	X	X	?		X		severe on fine turfs (recommended for tall fescue)

[a]*Phytotoxicity can depend on environmental conditions, plant health and cultural practices.*

bers is not significant. On the other hand, season-long suppression would be undesirable because a plant needs to grow to rejuvenate itself.

An important characteristic for a highway PGR is the ability to suppress seedhead formation. Some grasses and weeds form extremely high seed stalks. If a PGR does not suppress the seed stalk, it defeats the whole purpose of the PGR. A mowing would have to be done to remove the seed stalk.

In low maintenance areas, such as highway turfs, broadleaf weeds are a component of the turf. Suppression or control of these weeds is an important consideration in using PGRs. A common practice is tank-mixing a PGR with a broadleaf weed killer such as 2,4-D, which can easily control weeds such as dandelion, dock, wild carrot, pigweed, plantain, and thistle.

Grass growth & development

Deciding on the "ideal" PGR for highway turf requires the user to understand the effect PGRs have on plant health.

Growth regulators, unfavorable environmental conditions, or other factors that retard tiller and leaf initiation and development can result in a reduced population of leaves and tillers, lower turf density, and, in turn, reduced grass quality.

A reduction in grass density will also favor the encroachment of undesirable weed species, further detracting from quality.

Lateral shoot growth and the development of new shoots from vegetative buds on rhizomes and stolons enhance the recuperative potential and rate of many grass species (e.g. Kentucky bluegrass and creeping bentgrass). Recuperative potential is especially important on grass sites that are injured by traffic or other mechanical or biological factors.

Suppression or control of weeds is an important consideration in using PGRs.

Growth regulators inhibit the initiation and/or development of secondary lateral shoots. Interference in root initiation and development will obviously deter from the maintenance of high quality turf. Growth regulators have been shown to interfere, to some extent, with these normal root renewal processes.

Plant growth regulators

The current PGRs available for turfgrass use are listed in Table 1.

Maleic hydrazide was the first growth regulator available for turf, and has been used in rights-of-ways in a number of locations. It suppresses turfgrass growth by inhibiting cell division in the shoots, roots, and buds of the turfgrass plant. Maleic hydrazide's broad activity in the root and bud areas has caused restricted root and rhizome growth of Kentucky bluegrass. Its use has been limited primarily to low maintenance areas because of possible phytotoxicity and excessive inhibition of plant growth under stress.

Mefluidide (Embark) is one of the newer plant growth regulators. Mefluidide suppresses vegetative growth and seedhead production, and inhibits cell division and meristematic activity in plant areas that contact this PGR. It is absorbed by the foliage, but is not as readily translocated in the plant as maleic hydrazide. This is a possible reason that root and rhizome suppression does not appear to occur with mefluidide.

Flurprimidol (Cutless) is also a new PGR that has good vegetative growth suppression and some weed suppression. Flurprimidol has been ineffective for seedhead suppression in some research studies. Its inability to consistently inhibit seedheads is a negative factor in highway rights-of-way situations. However, combinations of flurprimidol and mefluidide are alternatives where seedhead suppression is desired. Flurprimidol has shown some activity

Continued on page 46

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Let us send you a sample of Fe^{++}RROMEC™ so you can see with your own eyes how fast it changes weak-looking dull grass into vibrant, deep-green, healthy-looking grass.

Everett Mealman
President
PBI/Gordon Corporation

As a professional golf course superintendent or groundskeeper, you will immediately recognize the significance of what I am about to say . . .

. . . We at PBI/Gordon have been quietly testing our patented Ferromec under a wide variety of growing conditions, and the results are conclusive! . . . Ferromec will not only deliver rapid and dramatic color responses in turf as a result of foliar intake, but will also deliver a therapeutic dose of iron to the turf through root absorption.

It means that now you can have deep, vibrant, healthy green turf without an unwanted overdose of fertilizer which could lead to all sorts of problems and exposure to disease.

No wonder we are so eager to get a sample of Ferromec in your hands. But, meantime, we urge you to take a minute or so to better understand why iron is such an elusive material, and how PBI/Gordon has managed to harness it for you.

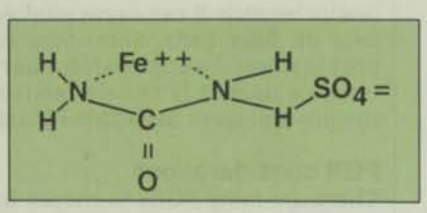
Ferrous Iron is Very Fragile.

As you know, the basic problem of supplying iron to turfgrass is its fragility in the Ferrous++ state. Only Ferrous iron can be utilized by a plant and, *ironically,* almost as soon as Ferrous Sulphate is applied it turns to the non-usable Ferric+++ state. Once oxidized, the reversal with organic matter acting as a reducing agent is so slow there is a question if it would ever occur.

And thus it is that scientists devised chelating, which is intended to fix the iron molecule in the Ferrous state. If chelating is properly done, it is effective.

Half of this green at Hodge Park Golf Course in Kansas City was sprayed with Ferromec and, within 24 hours, the color change was dramatic. Under normal growing conditions, visual response usually occurs between 8 and 48 hours after application. However, if moisture and temperature extremes exist, the response may be slower. Ferromec is also effective on trees, shrubs and herbaceous plantings.

Iron that Produces Within 24 Hours



This is the molecular structure of Ferromec. Note that ferrous sulphate is bonded to a urea molecule and will remain stable. Ferromec utilizes a recombinant urea process to achieve the unique composition. It is classified as an organometallic compound.

But it is very expensive and so slow to release that it could be many weeks before a treatment of chelated iron could produce a significant color change in the grass.

Ferromec Works Right Now!

At PBI/Gordon we have a patented process of bonding a Ferrous iron molecule to a molecule of urea, which stabilizes the iron in a Ferrous state. Notice the diagram above of the Urea/Ferrous sulphate molecule which is called Ferromec.

Ferromec can be mixed with liquid fertilizer and Super Trimec® broadleaf herbicide, and it will not harm the equipment. The Ferromec is almost immediately assimilated so the color change occurs very rapidly. The Ferromec which reaches the ground is taken up by the root system because the grass has such a voracious appetite for the nitrogen content of Ferromec.

Neal Howell Can Answer Your Questions about Iron in Turf

Iron is definitely established as an essential micronutrient required by all plants. Yet, the amount required can vary dramatically depending on the pH of the soil, the composition of the fertilizer that is being used and the plant that is being fed.

To help you better understand how to use iron in your turf program, we have brought Neal Howell into the PBI/Gordon organization as Director of Technical Sales Services of Soil Supplements. He is a leading authority on iron and is as near as your telephone when you have questions.

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PGRs *from page 42*

on poa annua suppression (control) in fine turf situations.

Amidochlor (Limit) is a root-absorbed PGR, thus requiring moisture within 3-5 days after application to wash it into the root zone. Amidochlor has shown both vegetative and seedhead suppression. No apparent root growth suppression has been associated with amidochlor.

EPTC (Short-Stop) is a new PGR that is recommended for use on tall fescue because it can cause phytotoxicity on finer turfs. Short-Stop does provide weed suppression characteristics since it is closely related to the pre-emergent herbicide Eptam.

PGR considerations

There are more PGRs to choose from then ever before. With the new PGRs and new experimentals being tested, the future looks promising.

The slow growth rate of turfgrass plants treated with a PGR retards the recuperative potential of the plant.

One note of caution is to always analyze the situation in which you use the PGRs. A PGR may show differential activity for different grasses.

For example, tall fescue and perennial ryegrass are generally more difficult to suppress than Kentucky bluegrass. Plant growth regulators by their nature inhibit the renewal process of turfgrass plants. Renewal of leaves and tillers is a necessary process to sustain quality turf.

Plant growth regulators, unfavorable environmental conditions or any factor that reduces tiller and leaf initiation results in lower turf density. Lower density can favor weed encroachments, loss of turf/soil stability, erosion, excessive water runoff and other related problems.

Disease incidence has been more prevalent on turfgrasses treated with a PGR. The slow growth rate of turfgrass plants treated with a PGR retards the recuperative potential of the plant.

These factors are important in deciding if a PGR is right for a specific situation.

On highway rights-of-ways, turf quality is of less concern than other factors, but functionality (density) with regard to turf/soil stability and erosion are critical in deciding on a PGR along with repetitiveness of its use and site selectivity. **WT&T**


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Monsanto, the company that brought you Roundup® herbicide, now brings you another important turf management tool. LIMIT turf regulator is the guaranteed way to slow the growth of bluegrass, fescue, and ryegrass for up to six weeks.

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Grounds Supervisor,
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JOE KOSOGLOV
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- Can be tank-mixed with fertilizer and commonly used turf herbicides for one-pass convenience.
- Easy to mix and apply.
- Available in quart or gallon size.
- Monsanto guarantees LIMIT will perform as promised on the label. *(Always read and follow label directions.)*

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Try new LIMIT where you want to mow and trim less. A lot less. And give your crew better things to do.

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President
Wright Lawn and Tree Care, Inc.
Clarence Center, NY

"We've had phenomenal results with LIMIT at two cemeteries. For the first time, we can tell our accounts we have a product that will consistently work."

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LIM-6-104

WEED FREE

For scenic roadsides, deeply-rooted plants are needed to successfully battle weeds for water and nutrients. That means developing a sound fertilizer program.

by C. Robert Staib,
Nor-Am Chemical Co.

Only slow-release nitrogen should be used in the planting hole. This is also the best time to incorporate phosphorus in the planting medium.

America the Beautiful" is an appropriately descriptive phrase, in part because of the country's highway system. Miles and miles of weed-free scenic roadsides are taken for granted by the traveling public. Only the landscape manager realizes the complexities of establishing and maintaining "that to which we have become so accustomed."

Developing a sound fertilizer program can help the landscape architect and horticulturist or agronomist to achieve their goals. Besides the beauty and functionality of roadside plantings, more vigorous growth helps keep a weed-free environment less dependent on expensive herbicide applications.

Healthy root systems

The long-term success of the roadside landscape is dependent on many factors, including availability of water, good drainage, and ability of plants to withstand effects of salt, auto exhaust emissions, and herbicides.

Roadside developers and agronomists know full well that maintenance resources are limited, and many times their plantings will have to fare for themselves. This is only possible when plant roots are firmly established, and thriving as deep as possible in the soil profile. The growth of plant vegetation is accompanied by a corresponding demand for carbohydrate reserves from the root system.

Healthy, deep roots, therefore, are vital to foster vigorous growth and plant density for long periods in diverse soils and weather conditions.

Key macro-nutrients

Most commercial fertilizers used in the landscape consist of synthetic organic nitrogen (urea, slow-release or coated products) plus reacted or mined phosphate and potassium sources (potassium chloride, also known as muriate, or potassium sulfate).

Nitrogen, phosphorus, and potassium, the major nutrients, are required by plants in the greatest quantity.

Of these, nitrogen is the most important, and is required in the highest amounts. Next in importance is potassium, required to sustain cellular structure and strength of the cell wall. Phosphorus, vital in the process of energy transfer within all living tissue, is nevertheless used in much smaller amounts.

Research shows that potassium levels of 50 percent of applied nitrogen (or even higher) are highly beneficial to turf. Except in extreme situations, residual soil phosphorus is generally sufficient to meet the needs of grasses and groundcovers once they become established.

Secondary nutrients

Calcium, magnesium, and sulfur are important in carrying out or supporting metabolic processes. These nutrients are also important in the development of soil characteristics favorable for plant growth.

Studies have shown that low rates of water-insoluble nitrogen applied in the sodbed prior to laying sod encourages rapid root growth. A firm early knit of sod is important on erosion-prone cut and fill slopes along roadsides.

C. Robert Staib, senior sales representative for Nor-Am Chemical Co., is based in Des Moines, Iowa. He is involved in sales and technical service to the turf and ornamentals market. This article was prepared for presentation to the National Roadside Vegetation Management Association, Kansas City, Mo., Oct. 8, 1985.

Tree planting positions are marked out with piles of slow-release ureaform. Auguring through the pile thoroughly mixes the fertilizer with the backfill soil as the hole is dug.

Calcium and magnesium are important components of organic matter which provide stability to soil aggregates.

These elements in the carbonate form help achieve a more neutral pH in acid soils, while sulfur is used to lower the pH of alkaline soils. A nearly neutral pH allows maximum availability and utilization of plant nutrients.

Minor plant nutrients include iron, manganese, zinc, copper, boron, and molybdenum. Except in very unusual situations, iron is the minor element most likely to be deficient.

High pH and high phosphorus levels in the soil can create iron deficiency. In both cases, iron is precipitated to insoluble, unavailable salts. Correcting soil pH and applying iron in fertilizer or as foliar sprays will correct the situation.

Nitrogen availability

The process by which fertilizer nitrogen becomes available in soil is called *mineralization*.

The rate at which urea mineralizes to ammonium ions (which then nitrify to nitrate nitrogen) is quite rapid, occuring over two to seven days at temperatures above 50 degrees F.

Nitrate (NO_3^-) nitrogen is the form most rapidly absorbed into the plant system. Highly water-soluble nitrate ions are subject to leaching, and in coarse soils excessive moisture can result in significant nitrogen loss.

Another avenue of N loss is via ammonia volatilization. In addition to ammonium ions (NH_4+) which are absorbed on clay and organic matter particles, some urea may hydrolize to ammonia (NH_3) which is subject to volatilization.

Improving plant vigor and density with a sound fertilizer program establishes an environment least favorable for weeds and scrub brush.

This is more pronounced in high pH soils, and can account for 25 percent or higher nitrogen loss. Nitrogen fertilizer made from ammonium salts, (e.g. ammonium sulfate, di-ammonium phosphate, ammonium nitrate, etc.), though water-soluble, are less subject to volatilization than urea.

Fertilizer programs

Few soils in a new right-of-way or rest area contain adequate major plant nutrients to forego applying commercial fertilizer. The establishment phase of roadside landscaping is the most critical in terms of assuring vigorous growth and long-term survival.

Spring is a good time to apply nitrogen, phosphorus, and potassium, and may be the only time that many miles of roadside vegetation will ever receive these important nutrients.

This is all the more reason to consider a nitrogen program that encourages strong rooting and extended availability over many months of growing season, though fall fertilization on cool-season grasses is also recommended if possible.

Commercial farm-grade nitrogen fertilizers are inexpensive and easily obtainable. However, they are water-soluble, release nitrogen rapidly, and generally have high salt indexes which can off-set their beneficial effect on new seedlings and small plants.

Besides the possibility of nitrogen loss, the faster release of N from these sources encourages too rapid growth of vegetative tissue. The consequences can be a shallow, less developed root system, poorly equipped to sustain grasses, trees, and shrubs through years of varied, often stressful growing conditions.

As previously mentioned, it is particularly important to get phosphorus down at the time of planting since it has its greatest influence on seedling establishment and root formation.

Since neither phosphorus or potassium move rapidly through the soil, regular farm-grade sources of these nutrients are both efficient and economical.

Low or no-N, high P-K fertilizers such as 6-24-24 or 0-20-20 are ideal sources of phosphorus and potassium, and are easily obtainable through farm fertilizer distribution channels.

Potassium's role in plants, both constructive and protective, is important in maintaining rigidity and integrity of cell walls, and helps to protect plants from disease and environmental stress.

Phosphorus is a key element in cell metabolism and energy transfer. Once plants become established under adequate levels of N, P, and K, the natural recycling of these nutrients from soil to plant to soil helps to satisfy long-term requirements. Also, deep roots can tap these elements where they exist at residual levels in the lower soil profiles.

The major nutrient

Nitrogen is so important in plant growth that it demands primary consideration when choosing a fertilizer. Several slow-release N sources are popularly used in landscape design.

If multiple applications of fast-release N sources are impractical, slow-release N fertilizers become a logical alternative.

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Use pesticides effectively. Read and follow label directions carefully.

Circle No. 154 on Reader Inquiry Card

How much N, P and K?

Because of the author's experiences, recommendations are based on using ureaform nitrogen in a single application at planting time, or once a year or less often under maintenance conditions.

Other slow-release N sources are suitable for long-term effects, and should be considered over fast-release fertilizers for these infrequent applications. For the purpose of clarification, "luxury turf" is defined as that composed of improved varieties of turfgrass cultivars mowed and maintained for aesthetic appearance near buildings and along urban parkways.

Seedbeds, luxury turf

400 lbs. ureaform, 38-0-0, (152 lbs. N) + 400 lbs. 6-24-24 (or other high P-K fertilizer) per acre, applied separately* or blended.

Seedbeds, low-maintenance grasses and groundcovers

200-lbs. ureaform, 38-0-0, (76 lbs. N) + 200 lbs. 6-24-24 (or other high P-K fertilizer) per acre, applied separately* or blended.

(* In seedbeds, phosphorus and potassium will be more efficiently utilized over a longer period if incorporated in the top three-to-four inches of the soil prior to seeding. The nitrogen fertilizer should be surface-applied for best results. Mulching or slight incorporation will help prevent rainfall from moving particles away from the site of application.)

Under sod

115 lbs. ureaform, 38-0-0, (44 lbs. N) + 200 lbs. 6-24-24 (or other high P-K fertilizer) per acre. Equivalent to 1 lb. N per 1000 sq. ft. Slightly incorporate into the soil surface prior to laying the sod.

Established luxury turf

400 lbs. ureaform, 38-0-0, (152 lbs. N) + 200 lbs. potassium sulfate, 0-0-50, (or 150 lbs. potassium chloride, 0-0-60) per acre. Apply in spring or early fall.

Established low-maintenance grasses and groundcovers

200 lbs. ureaform (76 lbs. N) + 100 lbs. potassium sulfate, 0-0-50, (or 75 lbs. potassium chloride, 0-0-60) per acre. Apply separately or blended, spring or early fall.

Tree establishment (bare root or ball and burlap)

½ lb. ureaform, 38-0-0 + ½ lb. single super-phosphate, 0-20-0, per ½-inch trunk diameter.

Mix fertilizer with backfill to be replaced in the planting hole. *Application technique tip*.....Mark out the planting hole locations wih pre-measured amounts of fertilizer. Power-auger directly through the pile, automatically blending the fertilizer with the back-fill as the hole is dug.

A soil test may indicate that levels of phosphorus and/or potassium are adequate to sustain growth. If so, apply ureaform only. If potassium is required, it is best to apply it on the surface in order to dilute the salt concentration in the vicinity of the newly planted roots.

Seedling trees and shrubs

2 ozs. ureaform, 38-0-0, + 2 ozs. of a high P-K fertilizer, surface broadcast around each planting. In an area of many closely spaced plantings, surface broadcast 400 lbs. ureaform, 38-0-0, + 400 lbs. of 6-24-24 (or other high P-K fertilizer) per acre. Apply separately or blended.

Established trees and shrubs

Surface apply ½ lb. ureaform, 38-0-0, per inch of trunk diameter uniformly beneath the canopy.

Trees and shrubs almost always will exhibit a response to nitrogen fertilization. Trees showing an unusually pale leaf color may be suffering from iron chlorosis. This is mostly a problem in alkaline soils. It can be corrected with iron chelate.

—*C. Robert Staib.*

C. Robert Staib, Nor-Am Chemical Co.

The three most popular of these are SCU (sulfur-coated urea), IBDU (isobutylidene diurea), and ureaform. The mode of release from each of these varies considerably.

SCU, 32 percent or 37 percent, releases nitrogen by diffusion through cracks, pinholes, and fissures in the coating. Typically, a third or more of the N is released in one week following application, with the remainder available over the next several weeks.

However, any stress—mechanical or weathering—affecting the coating will increase the rate of diffusion. It is faster in warm soils, and particularly so following rapidly alternating wet and dry periods.

IBDU (31 percent N) releases nitrogen via hydrolysis to urea in the presence of moisture. Large particles of IBDU hydrolize more slowly than fine-grade product, and affect a more sustained release during wet weather. Little nitrogen is released from IBDU when moisture is lacking.

Ureaform (38 percent N) is a reaction product of urea with formaldehyde, forming carbon: nitrogen linked polymers of varying chain length and solubility.

The shortest-chain polymers are sparingly soluble in water, while intermediate and long-chain polymers are water insoluble. These polymers, or compounds, are known as methylene ureas.

Nitrogen is released by soil bacteria feeding on the polymers. The short-chain C:N linkages are more readily digestable.

Under growing-season conditions, about ⅓ of the N is released in four-to-six weeks, ⅓ at two-to-12 months, and ⅓ over one-to-two years. A slight residual amount will carry over to be available the third year following application.

Research at the University of Illi-