WINNING WITH TURFGRASS GROWTH REGULATORS

J. E. Kaufmann
Monsanto Agricultural Products Company
St. Louis, MO

The title of this article implies that there are chances of something less than winning. In fact, many users have found unexpected results with turf growth regulators and are hesitant about using them further. This article addresses certain physiological processes of turfgrass growth and development that were obscured during the revolution of turfgrass science and management that occurred in the 1950's. Briefly, development of efficient mechanical mowers and fertilizers designed specifically for turfgrass resulted in a rapid improvement in the ease of maintaining aesthetic quality in large acreages of turf. Turfgrass research on the life-cycle of cool-season grasses, particularly on the seedhead or reproductive phase, more or less ended at that time as these processes could be rather easily obscured through mowing and other management practices.

For years researchers have said that mowing results in a series of developmental and physiological processes in the plant such as synthesis of the growth hormone ethylene at the cut end of leaf blades and subsequent stimulation of tiller development. It is believed that these processes currently associated with mowing are again altered when the practice of mowing is reduced or eliminated. It is further believed these processes are important in describing a large part of the erratic turfgrass response to growth regulators both in turfgrass quality alterations and in growth suppression.

Turfgrass quality reductions during chemical growth suppression can result from a myriad of factors. Certainly chemical injury is one of them. Some regulators are quite safe on the turf sward while others are very difficult to apply without injury. Consult the label directions to determine relative safety of each product. However, the turfgrass quality issues emphasized in this article are those that appear at certain times with all regulators and are a result of natural leaf aging, senesence and death.

Growth regulators work. Some work differently than others. Achieving consistent, uniform results is easy when the right product is applied correctly in the proper situation. This article will also examine basic application techniques and will compare some basic technical properties of current commercial and experimental growth regulators so that successful use of each can be optimized.

WHY USE GROWTH REGULATORS

Turf managers who have used growth regulators successfully indicate that growth regulators help them gain control over their operation in the spring when all the consumers have spring fever, the boss wants all the spring clean-up work and all the new projects done right now, the crew is short because the summer students are still in school, the grass grows fast, and you can't get out to work half the time because it's raining. Most managers agree that growth regulators do not replace mowing, but can successfully be used to regulate mowing and thus provide for more uniform seasonal mowing practices. The most effective method of determining where to use a growth regulator is to identify the acres of turf that: 1) need to be mowed on a frequent basis, 2) are slightly away from the "showcase" areas that build the image of the operation and 3) for one reason or another are difficult to get mowed on a timely basis each spring.

TIMING THE APPLICATION

Plant growth regulators (PGR'S) for turfgrasses have usually been recommended for application at specific times of the year. Spring is the most common time of the year for application because cool-season grasses exhibit up to 50 percent of their total annual vertical growth during a six week period that usually begins sometime in April and ends sometime in June. Naturally, the preferred time to apply a growth suppressing chemical is just prior to the peak growth period.

In the summer, PGR's are not widely recommended for use because warmer temperatures have already slowed growth, and little benefit can be derived from further reducing mowing frequency. In addition, summer is usually the period of highest traffic on turf and growth regulators have been shown to slow recuperation from wear stresses.

The fall represents an alternative application period to spring. Because of short days and cool temperatures in fall, cool-season grasses grow horizontally in preference to vertically. Much of the growth results in tiller and rhizome development. Thus, mowing frequency in the fall is not as great as in the spring and the need for a growth suppressor may not be as great. Further, the horizontal growth habit of the plant is important for improving density of thin turfs and PGR's may slow that development.

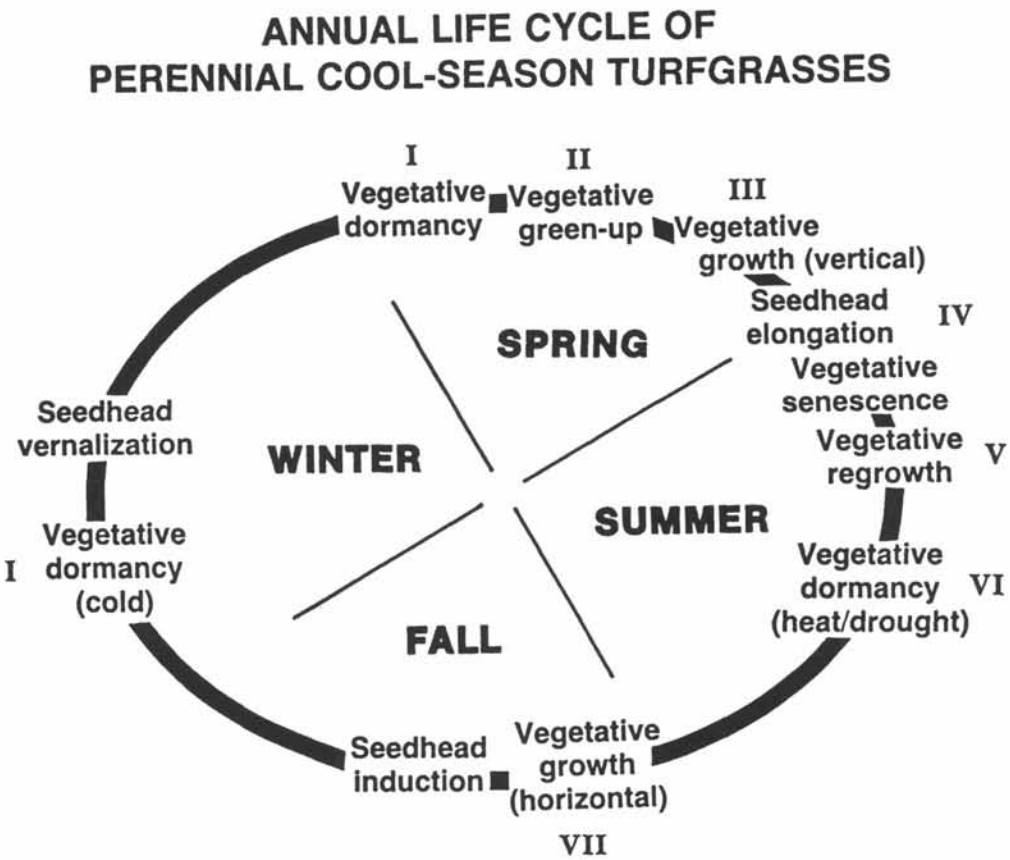
The method for describing proper spring application timing for most PGR's usually centers around green-up or spring growth. Terms often used include full green-up, 100 percent green-up, initiation of active growth, commencement of vertical growth and/or first need to mow. However these descriptions do not identify the other stages of development or the consequences of PGR application at those other times.

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

STAGES OF SPRING GROWTH

Figure 1 outlines the annual life-cycle of cool-season grasses and identifies proposed growth stages: I) Cold dormancy, II) Green-up, III) Rapid vertical growth, IV) Reproductive physiology V) Revegetation, VI) Heat and drought dormancy and VII) Fall revegetation. Since spring is the preferred time of application, only the first five stages are discussed in this article.

FIGURE 1



Stage I. Dormancy or Pre-greenup

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

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

Stage II. Greenup and initial growth

As temperatures begin to warm, new leaves grow from the crown apex (growing point) within existing leaves. Older leaves degrade and are replaced by new leaves. This process, known as greenup, may occur over a period of several weeks depending on how fast soil temperatures rise.

Late fall or early spring nitrogen applications promote grass growth and hasten the green-up process. Initial growth of spring-fall disease organisms such as leafspot begins at this time although infections usually do not appear on the leaves.

If this stage is prolonged by continued cool temperatures, the turf may reach 100 percent greenup while achieving only minimal vertical growth. During such a prolonged period, excessively high levels of disease populations can develop and subsequent leaf damage can begin. High amounts of rain and high relative humidity may further encourage disease development.

Stage III. Rapid vertical growth

The beginning of Stage III is most easily characterized by the need to mow. The grass is beginning to grow so fast that weekly mowings often remove much more than the recommended 1/3 to 1/2 of the existing leaf height. If spring season temperatures warm rapidly and consistently, this stage can be entered before 100 percent greenup, and more than one mowing may be required before complete greenup has been achieved. At the onset of this stage, development of spring-fall diseases is greatly reduced by warm temperatures but some leaf symptoms may still develop. Rapid turfgrass growth masks the disease symptoms.

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

Stage IV. Reproductive physiology

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

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

Stage V. Revegetation

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

LIFE-CYCLE VARIATION AMONG SPECIES AND VARIETIES

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

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

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

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

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

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

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

CHARCTERIZING THE GROWTH REGULATORS

Growth is often defined aq irreversible enlargement in size while development is transformation of apparently identical cells into diversified cells and plant organs. Based on these definitions, the current turf growth regulators can be divided into two types. Type I are those that affect both growth and development (Figure 2). Development not only includes the transformations from a seed to a mature plant in an annual species, but also includes the stages of the annual life-cycle within a perennial plant as shown in Figure 1.

FIGURE 2

TYPE GROWTH REGULATORS
Growth & Development
Suppression (1)/inhibition (2,3,4)

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1. Amidochlor - Limit™
2. Mefluidide - Embark™
3. Chlorflurenol - Maintain CF-125™
4. Maleic hydrazide - MH-30

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

Other chemicals known to inhibit growth and development of cool-season grasses are shown in Figure 3. These are defined as the herbicide type because all have a primary use as a herbicide. The herbicide types are characterized as having a very narrow margin of safety on cool-season grasses and accidental overdoses can quickly and easily kill turf. However, the sulfonyl ureas will likely find use along roadsides as a grass growth inhibitor but the primary benefit is long term broadleaf weed control.

FIGURE 3

HERBICIDE TYPE I GROWTH REGULATORS
Growth and development inhibition/kill

1. Non-selective herbicides
   Example: Glyphosate - Roundup™

2. Selective broadleaf herbicides
   Examples: Sulfonyl ureas - Telar™, Oust™

3. Selective narrowleaf herbicides
   Example: Sethoxydim - Poast™

Type II turf growth regulators are those that suppress growth only (Figure 4). The developmental sequence of the plant continues, however new plant organs develop in miniature size. Examples of this type include paclobutrazol or PP-333 and flurprimidol also known as EL-500 or Cutless. These compounds are often referred to as the anti-gibberellins and are effective internode elongation suppressors.

FIGURE 4

TYPE II GROWTH REGULATORS
Growth suppression only

1. Paclobutrazol - PP-333

2. Flurprimidol - Cutless™

LIFE-CYCLE RESPONSES TO REGULATORS

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

For the root active product, research has shown that applications made in Stage II from 70 to 100 percent green-up, have not shown excessive delay of green-up, especially where a fertilizer application was made at the same time. Applications at this time often result in slightly longer vegetative growth control compared to 5-6 weeks normally found at optimum timing. Seedhead control levels may be less than optimum when applications are made this early but usually remain at an acceptable 80 percent or higher.

As discussed previously, development of spring-fall diseases is more noticeable when grasses are growing slowly and further growth suppression with all PGR's during Stages I and II can result in increased visibility of disease symptoms. The following has been helpful in avoiding disease problems: 1) apply PGR's during Stage III where higher temperatures reduce disease development, 2) avoid applications to areas where common Kentucky bluegrass is under intense management, 3) avoid applications to areas having a history of spring disease problems and 4) use the products on areas other than the "showcase" turfs where disease cannot be tolerated.

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

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

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

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

TURF QUALITY ENHANCEMENTS RESULTING FROM PROPER TYPE I USE

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

WHAT ABOUT TYPE II REGULATORS

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

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

ROOT VERSUS FOLIAR ABSORPTION

Just as it is important to know where a pest lives in the turfgrass biosphere for targeting the pesticide application, the site of uptake of turf growth regulators needs to be identified and the growth regulator properly targeted to that site. The characterization of growth regulators in Figure 5 of soil versus foliar targeting indicates the optimum site of uptake for optimum activity.

FIGURE 5

Type of material	Biosphere targeting Soil	Foliage
PGR	Limit	
PGR		Embark
PGR		MH-30
PGR		Maintain
PGR	PP-333	
PGR	Cutless	
Herbicides	Pre	Post
Fungicides	Systemic	Contact
Insecticides	Most	

For Limit, PP-333 and Cutless, the products must be targeted to the root system of the plant. This does not mean the products are not absorbed by the leaves. In fact, leaf absorption may reduce product performance. Once inside the leaves, downward movement is not possible. Thus the only way for chemical to reach basal growing points of cool-season grasses is by root absorption and upward translocation. In the case of Limit, targeting must be done as soon as possible because it is highly biodegradable with a half-life of 1 week or less.

For Embark, MH-30 and Maintain, the products must be carefully directed to the foliage. Uniform and complete leaf coverage is important for uniform response from these products. All of these products require a period of time on the leaves for absorption before rainfall occurs or the products can be inactivated. This is especially true for maleic hydrazide which is slowly absorbed over a period of 24 hours. In addition, high humidities during the 24 hours are preferred to enhance the absorption.

On the other hand, root absorbed products are "weather-proof" in that immediate rainfall hastens and enhances activity. Given the frequency of rain in April, when application should occur over much of the midwestern and northeastern United States, the probability of natural rainfall soon after application is high, especially if the applicator merely avoids the first sunny day after a rainy spell. Many turf managers are applying root active products during the rain and thereby taking advantage of an otherwise "down" day.

Further, research has shown that root absorbed growth regulators have not shown direct chemical burn on turfgrass leaves and may be overlapped without noticeable injury. In other words any color loss due to improper application timing is not appreciably greater where overlaps occur. However, while overlap activity levels of Type I growth regulators are relatively similar to levels at the recommended rate, overlap activity of Type II growth regulators results in double the amount and length of activity. This results in uneven regulation of growth. Therefore, wherever growth regulator application has a high probability of resulting in overlaps, obvious ease of application advantages exist for root absorbed Type I growth regulators.

The herbicide, fungicide and insecticide information in Figure 5 is given to show biosphere targeting similarities only. For example, from a targeting point of view, it makes good sense to mix pre-emergent herbicides with root absorbed growth regulators. Both can and should be applied in a rain. On the other hand, post-emergent herbicides tanked mixed with root active growth regulators should be applied at least one day before anticipated rain. Always read label directions regarding compatibilities before mixing any chemicals.

EQUIPMENT FOR PROPER TARGETING

It is important to first understand that any equipment designed for uniform coverage can be used effectively for most products. However, certain equipment for soil targeted products is becoming more widely used because of increased flexibility in application.

Figure 6 shows that for foliar targeted products, finer droplet sizes, higher operating pressures and lower carrier volumes are achieved with flat fan nozzles usually mounted at predetermined intervals on a boom sprayer. The objective is to uniformly apply product to each leaf while minimizing runoff. This same objective can be met with ultra low volume micro-drop units or with mist blowers. The latter two pieces of equipment results in a great potential for drift of airborn particles. Foliage targeting equipment works well for root absorbed products since the next rain is the final carrier to the intended product destination.

FIGURE 6

SPRAY	EQUIPMENT
Soil	Foliar
Flood jet nozzle	Flat fan nozzle
Rain drop nozzle	Micro-drop ULV
Chemlawn gun	Mist Blower
Hose end sprayer	

However, the turf manager is increasingly utilizing single or multiple, large flood jet nozzles or rain drop nozzles that provide larger droplet sizes at lower operating pressures. These systems usually require higher carrier volumes. The objective is to provide uniform soil coverage while minimizing the amount of product remaining available for leaf absorption. This objective can also be met with the ChemLawn gun or hose end sprayer providing the operator is well trained.

For turf managers that desire to apply liquid forms of nitrogen this targeting objective is of critical importance to minimize leaf burn potential. Increasingly, turf managers are finding that these targeting objectives are also improving performance of soil active products that otherwise may be absorbed by the turfgrass leaves.

However, the key reason for choosing flood jet nozzles seems to be associated with the possibilities for lateral projection of product. High carrier volumes with large particle sizes can be projected laterally up to 15 feet either side of a single flood jet nozzle. Lateral projection means improved equipment maneuverability among obstacles and easier application under fences. The single nozzle is not subject to the variation of application rates and skips that are common in undulating terrain being treated with a boom sprayer. It is also not as subject to the variation that occurs when one wheel of the sprayer drops in a hole.

This type of equipment can also be used for foliar absorbed products. However, it should be remembered that just as some of the root absorbed materials may be partially absorbed by the leaves and rendered ineffective, this equipment will direct a portion of the foliarly absorbed product past the leaves to the soil which could result in less than optimum activity. In addition, larger droplet sizes will result in reduced ability to uniformly coat each grass leaf blade with the product. This could become important with products such as contact fungicides. Therefore, it is recommended that the turfgrass manager have both equipment types available for proper chemical application.

IN SUMMARY

The first and foremost ingredient for winning with turf growth regulators is to read and follow label directions for each product. However, a thorough understanding of the principles of growth and development of turfgrasses and how each product slows or stops grass growth and/or development becomes important in choosing the right product for the right job. Test the various products that are available commercially and experimentally. Winning with turf growth regulators is 1) choosing the right areas for product use, 2) applying the product at the right time, 3) using the right equipment, 4) targeting the materials to the right biosphere and 5) using the right product for the right job.