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EVALUATION OF SELECTED PLANT GROWTH REGULATORS
FOR USE ON HIGHWAY ROADSIDE TURFS

By

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ABSTRACT

EVALUATION OF SELECTED PLANT GROWTH REGULATORS FOR USE ON HIGHWAY ROADSIDE TURFS

By

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The cost of mechanical mowing of highway roadsides is very expensive. Some areas are very difficult or even impossible to mow because of slope, structures, sign posts and delineaters.

Chemical Plant Growth Regulators (PGRs) have been sought to reduce mowing requirements for more than 30 years. Amidochlor, Chlorsulfuron, EPTC, Flurprimidol, Mefluidide, MBR-18337 and PP-333 were evaluated at different rates and in different combinations on mixed and monostands of coarse and fine textured roadside grass species. The period of application for effective seedhead suppression was approximately: 27 Apr to 10 May for Mefluidide and 27 Apr to 25 May for Amidochlor in 1982; and for both Mefluidide and Amidochlor, 22 Apr to 15 May in 1983 and 20 Apr to 17 May in 1984.

Significant differences in vegetative and seedhead suppression were found among compounds and among dates of application. Synergistic effects were observed where Mefluidide and Chlorsulfuron were applied in combination. Tall Fescue (Festuca arundinaceae) was severely injured by Chlorsulfuron and Chlorsulfuron-Mefluidide combinations. Flurprimidol and PP-333 reduced seedhead height but did not reduce relative seedhead density.

Dedicated to my parents Thomas and Karen and to my brothers Douglas and Rodney, all of whom gave me their immeasurable love and encouragement at the times of my most desperate need. Without them I would have been lost.

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INTRODUCTION

Plant Growth Regulators (PGRs) for use on turfgrasses have been under investigation since the late 1940's. Maleic Hydrazide (MH) developed by the U.S. Rubber Co. was the first synthetic PGR to be used on turf, trees and ornamentals. Testing throughout the 1950's led to limited use of MH on roadsides and large trees. Results were variable and new compounds were being developed in the 1960's (CCC in 1960 and Chlorflurenol in the late 1960's). There have been many important improvements since those first compounds were tested. Today we have PGR compounds which provide more consistent responses over a wide range of vegetation management situations. However, there remains a gap between research results and what is found for commercial applications. The problem of phytotoxicity or discoloration is still a factor which limits PGR use to low and some medium quality turf areas. Reduced wear tolerance, weed encroachment, increased disease susceptibility, turf thinning and differential species responses resulting in uneven and poor quality turf surfaces are problems which must be resolved before widespread PGR use is accepted at most maintenance levels.

Both relative and vegetative growth can be controlled with certain of the modern PGRs. Selected compounds at specific rates will effectively inhibit vegetative growth any time of year as long as the grass is actively growing at the time of application. However, for

highway roadsides seedhead suppression is in many cases the primary form of growth regulation desired. The vertical habit of seedhead growth is responsible for the objectionable appearance of many low to high maintenance turfs during the peak times for seedhead production, which are spring and early summer for cool season species and summer for warm season grasses. Vegetative and seedhead suppression effects of individual PGRs vary among species with some grasses being more effectively controlled than others; this is termed "species specific effect". In most turf situations there are several cultivars or species in a mixed stand. This can lead to uneven vegetative height and inconsistent seedhead suppression. Timing of PGR application is very important when considering solutions to this problem. Each cool season grass species is stimulated to produce seedheads at different times throughout the spring which vary according to yearly weather conditions.

PGR compounds can be roughly grouped into one of two categories. Foliarly absorbed compounds are those which enter the grass plant by absorption through living foliage. PGRs of this type must be allowed to stay on the leaf for a minimum of several hours. Mefluidide is a foliarly absorbed compound. Crown and/or root absorbed PGRs form the second category. These compounds must reach the crown or root portions of the grass plant to be absorbed. It is necessary that chemicals of this type be "washed" into the crown and root zone of the soil surface by rainfall or irrigation following treatment. Granular PGR formulations must also be washed in. Flurprimidol, and Amidochlor would be included in the second category.

"Chemical mowing" is a term used when referring to PGR use in vegetation management systems. With proper use PGRs can reduce but not

replace all need for standard mowing practices. Mowing reductions of 50 percent or more have been shown by researchers and turf management professionals. If vegetative growth and seedhead production can both be inhibited to some degree, significant cost savings for fuel, labor, machinery, and maintenance could be expected even when mowing does become necessary. Additionally, turf quality may actually be enhanced even with less frequent mowing.

Michigan roadside managers have some unique problems when considering a PGR vegetative management system. First, the law requires that vegetative cover be established on slopes of all road construction sites prior to each winter season for erosion control. Roadside managers are inadvertently forced to use quickly germinating grass species, which are usually much less suited to an integrated PGR vegetation management system. Seeding mixes should be utilized to develop a plant community which has predictable PGR responses. This seeded mixture should then be used on sites where for convenience or by necessity future maintenance programs might include the use of PGR vegetation management systems.

Secondly, treatment of such large areas may be impossible, with respect to the critical time of application or "window of activity". This is the time span in calendar weeks during which any particularly PGR compound must be applied for maximum effectiveness. This is only critical for seedhead suppression. The treatment of thousands of miles of roadsides would only be possible if the "window of activity" were three or four weeks in duration or longer, meaning that areas sprayed April 15 react similarly to those treated May 15.

A third problem is that even with the most carefully conceived PGR

vegetation management systems, roadside managers will always have to contend with volunteer grass and weed species. Volunteer vegetation generally offers less predictable PGR response and therefore must be considered another problem to be solved while working toward refinement of these systems. Applications of weed control agents either alone or in combination with PGR treatments will be required.

There are also advantages when considering PGR application on Michigan roadsides. First, roadsides receive very little traffic or wear. This is important due to the reduced plant vigor and limited wear tolerance which result from treatments with currently available PGRs. Secondly, the acceptable aesthetic quality of a roadside is generally lower than other sites. For this reason, the inevitable interspecies response variation and the discoloration associated with the application of many PGR compounds may be better tolerated.

The study objectives were as follows: 1) To determine the "window of activity" of selected PGRs on highway roadside grass species. 2) To determine the activity of specific PGRs over a range of grass and weed species. 3) To evaluate selected PGR-Herbicide combinations for vegetative and seedhead suppression of grasses with weed control agents in a tank mix. 4) To evaluate the potential for reductions of mowing energy consumption. 5) To evaluate different PGR application rates for selected PGRs and PGR combinations.

LITERATURE REVIEW

The History of Plant Growth Regulators

Research with Plant Growth Regulators (PGRs) for use on turgrasses is not new. Since 1945 researchers have sought to reduce mowing by chemical means. The United States Rubber Company discovered Maleic Hydrazide (MH) in 1947. Juska and Hanson (46) stated that growth retardants were first used successfully in 1948. Other sources reported on initial or early use of MH in 1949 (79) and 1950 (27). Mathias et al., (51) mentions that the PGR activity of CCC (Chlormeoquat) was first reported in 1960. Steffens (63) stated that chlorflurenol (Maintain CF-125) was developed in the mid to late 1960's.

In 1965, PGR use on all crops with all compounds was about three million pounds (90 percent being MH); by 1972 use had grown to six million pounds annually (70 percent MH), and in 1975 MH accounted for only 50 percent of all PGRs used worldwide (27). The remaining 50 percent of the international PGR market had been taken up by newly developed PGR compounds, many of them second or third generation products. There were four million pounds of PGRs manufactured in the United States in 1976. At least three fourths of that amount was MH which was being used on tobacco to stop suckering after topping (63).

Steffens (63) reported that the total worldwide sales for PGRs (including defoliants and dessicants) in 1974 were about \$59 million and projected that by 1984 that figure might be up to \$150 million. Elkins and Suttner (21) estimated that in 1974, \$500 million was spent for highway right-of-way maintenance (mowing, manpower, equipment and chemicals) in the United States.

Agriculture chemical manufacturers have made a serious attempt to supply improved PGRs as the market expands. Since 1970, millions of dollars have been invested in the development and testing of new PGR compounds. Embark^R became commercially available for use on turf in 1978. Cutless^R was labeled for experimental use in 1984 and Limit^R will be available for commercial use in 1985. Today, MH is seldom used on turf because the new PGRs offer improved response. There is, however, still much to learn about their use in the complex plant communities typical of a turf sward.

Qualities of an Ideal Plant Growth Regulator for Turfgrasses

The following qualities have been suggested as those which would describe the "ideal" PGR for use on turfgrass. It should be noted that no currently available PGR completely fulfills all of the qualifications stated below. An "ideal" PGR should: 1) suppress but not entirely stop vegetative growth and produce no significant root growth inhibition. Tiller production should also be unaffected. This would enable the grass to retain its normal recuperative potential and stress tolerance (2,14,24,27,47,59,61,65,70); 2) provide a minimum of 5 to 6 weeks and preferentially up to 12 weeks of vegetative suppression (25,27,31,47,49,61,66); 3) the turf should resume normal growth after inhibition in

order to rejuvenate the sward (59); 4) provide the desired growth suppression without significant or long lasting turf injury (phytotoxicity or discoloration) at recommended rates of application (14,24,25,27,31,47,59,61,66); 5) show low toxicity to non-target plant species and be free of long term residual accumulation for environmental reasons (61,66); 6) be absorbed through the foliage as well as the crown and root portions of the plant (61). This would reduce the variation of effectiveness due to the changing weather conditions; 7) allow repeated application without dramatic negative effects, in particular turf density reductions and long term root inhibition (66); 8) provide vegetative and seedhead suppression over a wide range of grass species at recommended rates. This is necessary in order to provide an even turf surface (25,47,61,65); 9) have a reasonably wide "window of activity" for the suppression of vegetative growth and seedhead production (25,61). The "window of activity" is described as the time span in calendar weeks during which a particular PGR compound must be applied to achieve maximum effectiveness; 10) provide some amount of broadleaf weed control or form compatible tank mixes with appropriate broadleaf herbicides (25,61,66); 11) be effective at all levels of turfgrass maintenance (61); 12) be easy to apply with conventional equipment (25,61); and 13) provide economic benefits over conventional management practices (21,69). The cost of the PGR compounds and their application should not exceed the cost of one conventional mowing in order to be economically feasible on low use utility turfs (47).

"Chemical Mowing" and Other Uses in Turfgrass Management

"Chemical Mowing" is a term often used when referring to the use of

PGRs in vegetation management systems for turf (2,13,20,47,49,73,80). Chemical mowing specifically refers to the use of PGR chemicals to complement standard mowing operations by reducing the frequency of required mowing. Mowing reduction is sought to provide cost savings. To date PGR use has been limited to low use utility grass areas. These utility turf areas are, however, well suited to PGR use for aesthetic and economic reasons. The accepted level of aesthetic quality of utility grasses is not so high that some phytotoxicity or discoloration which is commonly associated with the application of many PGRs can be tolerated. Cost savings can be provided by reduced mowing on a site where high quality turf is not necessary. Many utility turf areas are difficult or even dangerous to mow due to severe slopes, frequent obstructions, wet spots and proximity to roadway traffic (2,4,5,8,10,11,13,14,41,47,56,57,65).

Mowing reduction on higher quality turfs is also possible but greater care must be taken to minimize loss of color and turf density as well as keeping a uniform surface appearance of the turf (14,65). Vegetative and seedhead suppression are both important when seeking to reduce mowing frequency regardless of maintenance level. Once matured, seedstalks dry out and become very tough which makes it more difficult to cut them cleanly as compared to the vegetative portions of the plant (8,10,13,41,57). For high maintenance annual bluegrass fairways and utility turf areas, seedhead suppression is of particular importance because it is the seedheads which give the turf an unsightly appearance. Heavy spring seedhead production of annual bluegrass turfs produces an objectional appearance which mowing does nothing to improve (42).

For some turf situations, PGRs may be used to enhance turf

tolerance to water stress and reduce the fertility requirements (11,47). This is accomplished by reducing vegetative growth which reduces the leaf area subject to evapotranspiration, thus reducing water demands. Additionally, less vegetative growth may require fewer nutrients for plant metabolism (11).

Overseeding operations in turf are regularly used on warm season golf turfs in transitional climates. Also, other forms of overseeding are used in a wide variety of turf maintenance programs. PGRs can be used to reduce competition from the original turfgrass while the overseeded species become established (20,28, 83).

Some PGRs reduce the elongation of seedstalks but do not affect seed production (7,10,44). These compounds can be used in commercial turf seed production to reduce lodging and improve yields.

PGR Use on Other Crops

PGRs are used in many other crop management systems. Often a compound commonly used on turf will have an entirely different trade name when sold in a different market. Mefluidide, the common name for Vistar, is also a grassy weed herbicide when used on soybeans and cotton (35,69). Steffens (63) reported that 80 to 90 percent of all tobacco is treated with MH to suppress sucking at axillary buds after standard top removal. The sprouting of potatoes and onions while in storage is inhibited by MH applications (63). Freeborg (28) reported the use of PGRs for ripening and to enhance the nutritonal value of forage corps. Orchardmen have used PGRs to reduce fruit tree pruning, improve fruit ripening and aid in mechanical harvesting of the fruit (1,10). Utility companies have applied MH to maturing trees under electrical power lines

to reduce the costly mechanical pruning required (33,63). Woody and potted ornamentals, shrubs, hedges and ground covers have all been shown to respond favorably to PGR treatments (10, 31, 33, 63).

Cereal grain producers can find benefits similar to those described for turf seed production. Stalk shortening reduces lodging and increases yields (10,17,63). Some investigators have reported net increases in seed production regardless of lodging. Hebblethwaite et al. (34) discussed hypotheses which might explain this phenomenon. It is thought that the effects of chemical suppression resulted in reallocation of photosynthetic assimilates within the plant. The energy which was to have gone into stalk elongation now will go toward greater seed production and increased loading of the seed produced.

PGRs are also used to reduce competition from the turf where a crop plant is to be established in a sodded field (20,28,30,31), Mathias et al. (51) reported the use of growth suppressants to inhibit grasses in a no-till corn production area. Competition from the grass could be reduced in the spring when the corn plants are young; then following harvest the land could be used for pasture. This was also advantageous for erosion control reasons.

Economic Benefit from PGR Use

Turf maintenance programs ranging from low to high intensity may find economic benefit from PGR applications. Savings can be found through reduced insurance, fuel, labor, machinery and maintenance costs (9,11,21,22,26,27,28,41,49,52,55). Many roadsides and utility turfs are difficult and sometimes dangerous to mow because of severe or rocky slopes, guard rails or frequent obstructions and proximity to highway

traffic (4,12,15,18,23,24,25,31,47,54,55,56,57,64).

Mowing efficiency can be improved with PGR treatments. PGRs suppress seedhead production (8,18,21) and vegetative growth so that when mowing becomes necessary there is less bulk and therefore easier cutting. The size, weight and energy requirements of the mowing machine needed will likewise be determined by the bulk of grass to be mowed (61). In his article written for American Lawn Applicatory Magazine Kaufmann (47) stated: "Rough estimates suggest that the cost of the chemical would equal one mowing and the cost of application another mowing. Thus the chemical must replace three mowings before it begins to pay off". Foote and Himmelman (26) concluded that MH applications would not be economical on rural sites where mowing was typically twice yearly. However, urban turfs which were mowed five to twelve times per season could benefit if five or more mowings were eliminated. Work done in West Germany by Schott et al. (60) showed mowing frequency to be reduced from twelve to three times per season with three chemical applications, one each in spring, summer and fall. Brenninger et al. (5) reported PGR treatments which eliminated twelve mowings on a tall fescue turf in 1980 in Pennsylvania. Chappel (8) estimated that mowing could be reduced 50 percent as a result of vegetative and seedhead suppression.

Water conservation as a result of PGR applications was reported for two warm season grasses by Johns and Beard (45). The conclusion of this work was that if the leaf area index were reduced then evapo-transpiration rates would be reduced proportionally. Considerable amounts of high quality turfs are grown in warm and arid climates where irrigation water is in limited supply and at premium cost. Irrigation

costs might be significantly reduced if high quality turfs could be treated with PGRs and deleterious side effects minimized.

Turfgrass Maintenance Categories

Three basic turf maintenance classifications exist, fine turf, medium turf and rough turf. Fine turfs are described as those which are mowed twelve or more times per season (61), this category includes: high quality home lawns, ornamental gardens, some office building lawns, golf course fairways, trim or border areas, sod farms, and overseeded cool season grasses in warm season turfs during winter on golf turfs in the southern United States.

Medium turfs are those which are mowed six to eleven times per season (61), turf areas in this category would be: some school grounds, many industrial grounds, institutions (hospitals and prisons) cemeteries, trim or border areas, medium quality home lawns, athletic fields, some areas of shooting ranges, large estate grounds, around trees and along hedges (2,3,66,76). PGR use on fine and medium quality turfs has been limited in the past because frequent discoloration and inconsistent responses found with some older PGRs. Due to the demand for higher aesthetic quality the deleterious side effects commonly associated with PGR application cannot be tolerated on these turfs. However, as we gain experience with currently available products and assuming that new and better compounds will be developed, PGR use in these areas is inevitable.

Rough or non-use turfs are described as those which are mowed up to five times per season (61), areas where aesthetic quality is not at a premium (76). Rough turf areas include: highway medians, roadsides,

around guard rails, utility rights-of-way, railroad rights-of-way, industrial grounds, institutions, around drainage structures, drainage canals and ditches, around culverts, grassed waterways, steep or rocky slopes, around fences, low maintenance lawns, low use park areas, golf roughs, shooting ranges, ski slopes, vacant lots, acreage for sale, pipelines, tank farms, airports, military installations, ammunition dumps and specific areas with high grass fire potential (2,31,59,66).

Warm Season versus Cool Season Grasses

Kaufmann (47) recommended in a popular article that growth retardants be applied so that growth inhibition coincides with the period of maximum shoot growth. For the cool season grasses this would likely be the spring season. For warm season grasses, the summer months. Periods of maximum seedhead production are approximately the same respectively. However, the duration of inflorescence is greater for warm season grasses which makes seedhead suppression more difficult with current products and procedures (49). Watschke (71) reported generally less discoloration on warm season grasses. Beard (2) found discoloration to be more severe on warm season species. PGR treatments have produced vegetative and seedhead suppression of both cool and warm season grasses. By far, the most uniform PGR effects have been observed on cool season species (2,3,49,56,61,62,71).

Mode of Action

PGRs are divided into two broad classifications: 1) terminal growth inhibitors, and 2) internode elongation inhibitors (27). Terminal growth inhibitors normally affect meristematic growth at shoot

and root terminal apices, either by inhibiting cell division or by causing death of these tissues. Internode elongation inhibitors typically do not have any effect on cell division. The compounds appear to interrupt the normal function of internal plant hormone systems either by inactivation or inhibition of biosynthetic processes.

MH is reported to stop cell division without affecting cell elongation and has been shown to cause chromosome breakage in some plants (2,26,36,66,83). Chlorflurenol is translocated via both phloem and xylem. Once the chemical reaches the terminal growing points of the plant it inhibits cell division and mitosis (29,63,65,66). Chlormeoquat or CCC inhibits internode elongation without any effect on apical meristems or apical dominance. Horowitz (36) reported that cell division and elongation were inhibited by CCC. Other sources suggested that CCC might inhibit gibberellin biosynthesis yielding internodal shortening (44,51,66). Ethephon stimulates ethylene production which causes dwarfing and stimulates lateral growth (29,36). Steffens (63) reported that Dikegulac has been shown to interact with gibberellins, auxins, kinetin and ethylene to inhibit DNA synthesis, but its initial effects may be on the cell membrane. PP-333 inhibits sterol biosynthesis leading to a reduction of plant gibberellins which produces shorter internodes and leaf blades (10,61). Gerrish and Dougherty (30) reported that Embark inhibited cell elongation more so than cell division. Field and Whitford (25) observed inhibition of both cell division and elongation with Embark treatments. Gross distortion in reproductive apices was observed, apparently due to uncontrolled cell division disrupting normal growth. Embark had very little effect on photosynthesis or respiration (25).

Morphological Effects

PGR effects on the morphological characteristics of treated grasses are contradictory. There appears to be a complex interaction between grass species, local environment, time of year, stage of physiological development and the individual PGRs. Fluorimide, MH, Chlorflurenol, and MH combined with chlorflurenol all inhibited root growth (84,85). Embark does not reduce root growth (25,73). Watschke (72) theorized that root suppression may actually be in response to less top growth and therefore result in less demand for water and nutrients. Field and Whitford (25) used germinating perennial ryegrass to illustrate this further. They found shoot suppression with no effect on root growth. Tiller production was unchanged, stimulated or inhibited depending on the PGR used. The same was found for rhizomes (29). Embark reduced tillering for a time after which tillering seemed to increase (30). Kentucky bluegrass tillering was reduced by CCC and Ancymidol (85). Increases in tiller production may be explained by reduced apical dominance due to seedhead suppression, and/or disrupted plant hormonal control which allows more axillary buds to form new tillers (17,30,44,61). PP-333 did not affect seedhead production but did shorten the seedstalks (17). Watschke (76) and Early (17) evaluated several PGR treatments and found none to have an effect on seed maturity or seed viability. Embark shortened the stalks of those few seedheads which did emerge and also delayed their emergence (25). Certain PGR treatments produced shortened plants and increased turf density (2,10,29,49,61,,84,85). Embark was shown to alter the leaf to sheath ratio which produced greater leaf area on a percentage basis (30). This

is considered a beneficial response for aesthetic reasons.

PGR Effects on Water Use Rate

In theory, water use rates can and would be lowered by PGR application (76). Mathias et al. (51) suggested that the amount of vegetative production is closely related to the water use rate of any turf. Watschke (77) reported that PGR treated field plots were more drought tolerant and exhibited fewer wilting symptoms. Greenhouse studies in England showed some water use reduction and improved drought resistance (61). Similar treatments in the field provided turf which was greener longer into the summer drought stress period. Johns and Beard (45) found reduced water use rates for two warm season grasses (mowed and unmowed) ranging from 11 to 29 percent. These responses were again attributed to less vegetative growth.

Application Timing

Inhibition of vegetative growth can be affected by treatment with selected PGRs at any time the grass plant is green and growing (31). Where maximum maintenance cost reduction is desired, PGR applications should be timed so that the inhibitive effects subside at a time when environmental factors will continue to inhibit plant growth naturally. Link et al. (50) noted that PGR applications made very early in the spring produced an inferior appearance because there had not been enough new growth to hide the dead grass tissue accumulated the previous season.

Seedhead suppression of turfgrasses growing in either monostands or polystands is more difficult and requires greater consideration on the

part of the applicator. The timing of the PGR application is most critical (3,4,14,18,25,28,61). For good performance PGR applications must be made not later than when the very first seedhead emerges. Several authors reported the best effects from treatments two weeks or more prior to seedhead emergence (4,8,42,43,65). The question of critical timing is much more confounding when management of a mixed turf (polystand) is desired. The optimum time for maximum control varies for each species or cultivar. Each grass is induced to flower and produce seed at different times throughout the spring for cool season species or summer for warm season types. The day or week where seedhead initiation occurs is regulated by yearly weather variations which are specific to each species and cultivar. Billot and Hentgen (4) and Gerrish and Dougherty (30) stated that PGR effects are dependent upon the morphological stage of plant development at the time of chemical application. Even further, there are distinct PGR compound by grass species interactions, resulting in uneven effects across species with identical compounds, rates and application techniques. Embark was reported to give good seedhead suppression from treatments applied April 12 through May 10, 1983 in Rhode Island. MH was less effective especially at the earlier dates of application (26,58).

Duell (16) observed a relationship between the time of application and the severity of phytotoxic injury for some treatments. Several investigators have evaluated PGR responses from spring, summer or fall applications either alone or in combination. A complete range of effects were found with spring applications generally the most effective but not infallible (6,9,26,46,58,60). Summer treatments provided both good (6,40) and poor results (22) and were found to give more severe

phytotoxic injury in general (25,47). Results from fall application ranged from excellent (9) to acceptable (9,22) and down to ineffective (26). Fall applications were reported to produce more discoloration or injury than spring or summer applications (6,66,76). The effects from fall MH treatments lasted longer the following season when applied closer to, but not later than the onset of winter dormancy.

The "window of activity"

For PGRs to provide seedhead inhibition, applications must be appropriately timed with respect to seedhead initiation for individual species. Hagman (32) described the "window for application" as the period between spring green up and seedhead emergence. Shearing and Batch (61) reported that the window for seedhead suppression was increased where Embark was combined with PP-333 when compared to the application of Embark alone. Field and Whitford (25) stated that: "...even small delays in the timing of application altered efficacy, with later applications often being less effective." Foote and Himmelman (26) and Freeborg and Daniel (29) report that the "window of activity" for MH is short (2-3) weeks and variable, which makes its use inconvenient for roadside maintenance programs. Eptam was reported to have a 4 to 6 week window of activity (8).

Repeat Application Effects

Depending on individual site, a PGR vegetation management program could call for one to three PGR applications per season on an annual basis. A single spring application may provide adequate vegetative and seedhead suppression where the diversity of the grass population is low.

However, split application may be required in order to provide consistent regulation where the sward is diverse (4). Results of other investigators vary dramatically on this point. Annual PGR applications were reported to have considerable negative effects (11,65) or no undesirable effects (8,60) on turf quality. Repeat applications within the same growing season were reported to severely reduce (24,37,41,46), slightly reduce (52,71) or have no effect (8,60,65,66,84) on turf quality. Where repeat applications proved beneficial the second treatment was often at one half the initial application rate (65,66,76,84). Although split applications were advantageous in some situations, the effectiveness of the second treatment was found to be less than that of the initial application (11,76,78,80,82). Watschke (76) and Watschke et al. (78) reported that effective suppression of the accelerated vegetative growth following initial PGR applications could be provided by a second treatment. However, it was recommended that the turf be allowed to grow for a time before the second or third treatment. This is necessary for plant rejuvenation which improves the stress tolerance of the turf and also allows any injured leaf blades (resulting from phytotoxic injury, disease or insect infestation) or senescent plant tissue to be hidden by new green growth (76).

Rates of Application

The amount of growth suppression and the severity of discoloration effects are related to the rate of application for any PGR compound. Beard (2) reported that red fescue is more tolerant to MH applications than are Kentucky bluegrass or colonial bentgrass. Rates found to be effective in suppressing growth caused undesirable discoloration to

fine-textured grasses (74). Light rates of Embark were not as effective as medium and heavy rates for vegetative suppression of annual bluegrass (42). Wakefield and Fales (70) reported excellent vegetative and seedhead suppression without additional injury on Kentucky bluegrass and tall fescue with two Embark rates; low at 0.56 kg/ha and high(2X) at 1.12 kg/ha. In 1972, Horowitz (36) reported that in general the level of growth suppression increased with increasing concentration of application. Also, some high rates were found to be lethal while other low rates stimulated grass growth. Shearing and Batch (61) reported that PP-333 treatments provided approximately the same degree of vegetative and seedhead control at all rates of application. However, the duration of the response increased as the rate of applications increased. Warm season grasses have a longer period of inflorescence than cool season species. This makes seedhead suppression more difficult from a single PGR application. The duration of seedhead suppression by Oust^R applied to bahiagrass and bermudagrass was proportional to the rate of application with low rates giving control but for a shorter period of time (49).

The efficacy of liquid PGR compounds is also affected by the volume of water in which the compound is applied. For foliarly absorbed PGRs the application volume must be high enough to provide consistent spray coverage and even spreading over the grass blades without washing off before absorption can take place. The volume and rate of application were reported to be key factors in the success of Embark applications (25). Kaufmann (47) recommended that foliarly absorbed chemicals be applied in one gallon or less per 1000 square feet. Crown and/or root absorbed compounds are not as critically affected by the volume of

application.

Liquid versus Dry Applications

Liquid application is the primary form of PGR treatment used in most turfgrass maintenance situations. The machinery needed for spray applications is more versatile (because it can also be used for weed, insect and disease control treatments) than dry spreaders, therefore, it follows that more turf maintenance operations will be equipped for liquid applications over large areas. Spray application is generally more convenient also, because less refilling is needed for treating the same area. Watschke et al. (75,76,77,78,79,80) reported that granular forms of PGRs (Embark specifically) produce lesser amounts of turf injury and that any injury which does result from dry applications was slower to show the symptoms. One study did, however, show injury to be greater with granular applications (80). Granular Embark treatments gave better shoot growth suppression than did equivalent rates applied in liquid form on a mixed stand of Kentucky bluegrasses and fine fescue (37), however, injury seemed to be greater for dry applications. Watschke et al. (78) and Jagschitz et al. (43) reported spray applications of Embark to be more effective than dry applications at equal rates.

Factors Influencing PGR Uptake and Efficacy

Plant absorption of PGRs is affected by: plant anatomy, plant metabolism characteristics, variations due to soil type and texture, environmental conditions at the time of application, and the specific chemical properties of the compound being used.

Wehner (82) reported that foliarly absorbed compounds were more quickly taken up and therefore began regulating plant growth sooner; however, the duration of effectiveness for these compounds was shorter than found with crown and or root absorbed compounds. The response from foliarly absorbed PGRs is dependant upon the length of time the compound is in contact with the foliage for absorption. If sufficient contact time is allowed excellent results can be found, if contact time is limited, inadequate uptake will result in poor growth suppression. Embark was reported to need a minimum of 12 hours of leaf contact (47) and MH 36 to 48 hours (2). Rainfall soon after treatment dramatically reduces the efficacy of both Embark and MH (61). Clearly this reduces the flexibility for widespread use of foliarly absorbed PGRs.

Field and Whitford (25) extensively studied the effects of Embark on perennial ryegrass. Embark was found to be transported throughout the plant via the phloem and xylem. Radioactive Embark was applied to individual tillers and traced throughout the plant. Other than the treated tiller, the greatest accumulations were found in untreated tillers and low amounts in the roots. The treatment of younger tiller leaves (which are excellent sites for PGR absorption) does not produce superior whole plant effects because at this stage of development there is almost no net export of photosynthates from these leaves. Mowing both before and after treatments reduced plant uptake of Embark but the pattern of uptake and distribution within the plant was unchanged.

Crown and/or root absorbed compounds are typically slower to act but their effects are usually more long lasting (77) and generally have much greater flexibility for application timing (61). For enhanced PGR efficacy rainfall or irrigation during or soon after treatment is needed

to wash the PGR compounds into the crown/root zone for plant uptake (47). PP-333 is absorbed through the stem and once it is washed into the soil, absorption continues through the roots (10). The efficacy of crown and/or root absorbed compounds would suffer only if rainfall was in great excess; heavy rains could wash the compounds completely away from the zone of plant uptake. Shearing and Batch (61) reported that high soil moisture enhanced the activity of PP-333.

In theory a PGR formulated as a "slow release" granular material could be very useful for improving the longevity of PGR effects in certain situations (76). The success of such an approach to PGR application would, however, be critically dependant upon timely irrigation or reasonably consistent rainfall. A development of this nature would improve the flexibility for timing of application considerably.

Climatic factors also influence PGR uptake by plants. Specifically, the plants reaction to its surrounding environment results in variable uptake of the PGR compounds. The efficacy of any PGR is affected by the prevailing weather during the period of chemically suppressed growth (30,60). Understanding the effects of weather and rainfall will help to explain year to year inconsistencies in PGR efficacy (29). Variations in seasonal weather patterns affect the metabolism of the plant which results in different rates of PGR uptake and variable efficacy (80). Gerrish and Dougherty (30) reported that the responses from Embark treatment were dependant upon the morphological stage of plant development at the time of chemical application. Embark treatments were reported to be only slightly affected by seasonal temperature variations (60). Several authors reported increased turf discoloration and

thinning when PGRs were applied while the turf was under heat and/or drought stress (22,60,66,72). Wakefield and Dore (69) proposed that the duration of discoloration can be partly attributed to differential species responses to climatic conditions.

Species Specific Responses

Freeborg (28) stated "a major difficulty is the tendency toward species response, so that if you have a Kentucky bluegrass, perennial ryegrass, fine fescue mixture, you will find that each one is inhibited differentially". Many other researchers have found this to be true for vegetative and seedhead suppression alike. Watschke (76) reported differential effects of identical treatments among bluegrass cultivars. Roadsides and other utility turf areas rarely have fewer than two or three grass species in a given area. This results in a difficult problem because it seems that each species (and maybe even cultivar) has the potential to react very differently from the others in the sward. This creates uncertainty as to a recommended rate of application for a mixed stand (22). Wu et al. (84) reported that PGR mixtures worked better for control of mixed stands of cool season grasses.

Further confusion results from conflicting reports of PGR efficacy on specific species. For example, Kentucky bluegrass suppression has been found with several PGR compounds (1,2,3,15,16,20,22,47,61,69,82). However, other reports contradict these findings (14,43,51,65). Street (66) reports that annual bluegrass is more sensitive to chemical injury than is Kentucky bluegrass. Redtop was described as "very sensitive" to MH (26). Shearing and Batch (61) stated that timothy and perennial ryegrass were less sensitive to PP-333 than were red fescue, bentgrass

or rough bluegrass.

In general seedhead suppression is more easily accomplished than vegetative control, however, application timing is critical and varies among species. Dore and Wakefield (13,69) ranked Kentucky bluegrass higher than red fescue for susceptibility to seedhead suppression. Watschke (76) reported similar findings. Sawyer et al. (57) reported that red fescue seedheads seemed to be more difficult to control than bentgrass seedheads. An earlier study by Dore et al. (14) reported just the opposite, that red fescue was more effectively controlled and less prone to injury than Kentucky bluegrass. In a trade publication Kaufmann (47) reported that Embark gave greater response on Kentucky bluegrass than on red fescue or perennial ryegrass. Embark gave more effective seedhead suppression for Kentucky bluegrass than tall fescue (20,82). In all, 41 of 85 cited articles mention varying successes for seedhead suppression with PGR treatments. The following information was taken from Table 32.10 in Shearing and Batch (61): Classifications of specific grasses for their sensitivity to PGRs.

Retarded

<u>Agrostis stolonifera</u>	Creeping bentgrass
<u>Agrostis tenuis</u>	Colonial bentgrass
<u>Bromus mollis</u>	Soft chess
<u>Festuca rubra</u>	Creeping red fescue
<u>Festuca ovina</u>	Sheep fescue
<u>Poa annua</u>	Annual bluegrass
<u>Poa pratensis</u>	Kentucky bluegrass
<u>Poa trivialis</u>	Rough bluegrass

Moderately retarded

<u>Agropyron repens</u>	Quackgrass
<u>Dactylis glomerata</u>	Orchardgrass
<u>Festuca pratensis</u>	Meadow fescue var.
<u>Holcus lamatus</u>	Velvetgrass
<u>Holcus mollis</u>	Rhizomatous Velvetgrass
<u>Lolium perenne</u>	Perennial ryegrass
<u>Phlem pratense</u>	Timothy

Slightly retarded/resistant

<u>Alopecurus pratensis</u>	Meadow foxtail
<u>Arrhenathrum elatius</u>	Tall oatgrass
<u>Bromus erectus</u>	Bromegrass (common variety)
<u>Bromus sterilis</u>	Bromegrass (common variety)

Effects of PGR-Herbicide and PGR-Fungicide Combinations

One quality of an ideal PGR discussed earlier was that an ideal PGR would provide some degree of broadleaf weed control or form compatible tank-mixes with appropriate herbicides. Likewise, some amount of disease control would be beneficial. Currently available PGRs do not provide adequate broadleaf weed control without the addition of an herbicide. Only PP-333 is reported to have any fungicidal activity (10).

Turf thinning often results from PGR treatment. This provides an opportunity for weed encroachment, which, if not controlled will lead to undesirable levels of weed infestation. Several authors have recommended supplemental chemical weed control to reduce weed proliferation (22,26,64,65,83). PGR treated turf has reduced ability to resist disease infestation and will not be able to grow and replace disease blighted leaves with new healthy blades until the effects of the PGR have worn off. PGR-fungicide combinations have been reported to reduce turf injury (which improves turf color) and reduce the incidence of disease without affecting the regulation of vegetation or seedheads (39,40,43,70,76). Jagschitz (39) suggested that fungicide applications improved turf quality by suppressing the incidence of disease and thereby reducing the accumulation of senescing plant tissues.

Effects of Mowing Before or After PGR Treatment

PGRs do not have the ability to provide season long growth

suppression without causing severe turf injury and thinning. Therefore, mechanical mowing will need to be included in any PGR vegetation management system. Duell et al. (16) stated that "a single mowing usually resulted in a more acceptable appearance for roadside conditions than did any retardant treatment".

Several studies have evaluated PGR efficacy where mowing was performed shortly before or soon after PGR application. Conflicting results have been reported. Dore and Wakefield (13) studied PGR effects when treated grasses were mowed at 2 1/2 and 4 inches prior to treatment. Their general findings were that the best effects were found on 4 inch turf with variable results for 2 1/2 inch and uncut turf plots. Elkins (18) reported that mowing prior to treatment stimulated seedhead production in some plots. It was also suggested that when mowing is done prior to treatment, at least one week should be allowed before compound application so that grass clippings are not shielding the live grass from treatment. Trim mowing after treatment was reported to improve the aesthetics of the turf surface without adversely affecting PGR efficacy (12,15,39,40,43). However, other reports showed that mowing after PGR application reduced growth suppression (23,25,46). Field and Whitford (25) reported that mowing four weeks after treatment released the grass from chemical suppression and stimulated additional growth.

The Effects of Nitrogen Fertilization on PGR Efficacy

Wakefield and Dore (69) theorized that nitrogen fertilization would increase the vigor and density of the turf and improve its general appearance following the period of chemical suppression. Their studies

showed that turf color and density were improved by nitrogen fertilization and that these improvements were found where injury would normally have been objectionable. Furthermore, there were only slight reductions in the effectiveness of the PGR treatments. Several other researchers have found nitrogen applications to reduce injury and thinning but at the same time shorten the duration of PGR effects (12,13,30,39,53,54,69,71,76,80). Elkins et al. (22) reported that heavy nitrogen fertilization had completely overridden PGR effects. Brown and White (6) reported that there was no interaction of nitrogen or potassium with Sustar or MON-0175 on the growth of 'Baron' Kentucky bluegrass. Dernoeden and Wehner (2) and Watschke et al. (80) reported that the frequently observed flush of growth after PGR effects have subsided, was increased where nitrogen fertilizer had been applied. A popular article written by Kaufmann (47) recommended that fertilization of PGR treated turf be minimized in order to minimize the post regulation flush of growth.

PGR Effects on Root Growth

Just as PGRs suppress vegetative growth, so do many of them also suppress root growth. Root suppression is an undesirable quality for a PGR compound as it will result in reduced turf quality due to reduced stress tolerance (65,66).

Wakefield and Dore (69) reported that root growth was suppressed similarly to shoot growth. Elkins et al. (19) stated that most PGR compounds which caused shoot suppression also caused root suppression. Embark has been reported to increase (27,45) slightly decrease (5,19,29,54,65,66,70,84), or have no effect (19,24,29,72) on root growth

of several grasses. MH, chlorflurenol, fluoridimide, chlormoquat, MH combined with chlorflurenol, MON-0175, and Sustar were reported to moderately to severely inhibit root growth at rates ranging from one half to two times the recommended rate of application (6,9,15,39,66, 70,84,85). Ancyamidol and CCC were found to suppress root growth only when applied at very high rates. EL-500 (Cutless) was claimed to improve rooting (28) or to have no adverse effect on root growth (2). Batch (1) working with cereal crops, reported root enhancement, supposedly due to PGR induced redirection of assimilates within the plant to favor rooting.

Field and Whitford (25) performed extensive studies to investigate the effect of Embark on root growth of perennial ryegrass. Pregerminated seedlings were treated with Embark and only shoot suppression was observed. Earlier studies had concluded that root growth was being directly inhibited by PGR activity. Field and Whitford observed shoot/root ratios over time and found that root growth followed a growth curve parallel to that of the shoot growth but about two weeks delayed. It was suggested that either or both of two factors might satisfactorily explain this relationship, first, reduced photosynthetic area (leaf area) might indirectly result in root growth suppression because the supply of assimilates available for root growth is reduced. Second, the demand for root growth would logically be diminished by reduced shoot growth which resulted in less water use and reduced nutrient quantity uptake. These results suggest that Embark does not specifically inhibit root growth.

PGR Effects on Tiller and Rhizome Production and Turf Density

Tiller and/or rhizome production are responsible for the vegetative density of any particular stand of turf. Seedhead production is also reliant upon tiller density because seedheads are initiated and produced by tillers (7). Several investigators report increases in tiller production as a result of PGR treatment (5,7,57,62,69,72,85). Buettner et al. (7) suggested that increased tiller production was a secondary PGR effect due to the direct inhibition of leaf growth. Jinks and Marshall (44) favor the hypothesis that PGRs interrupt standard plant hormonal regulation which then results in increased tiller production. Vernalization of tillers is often required before seedhead initiation begins for many grass species (48). Schmidt and Bingham (59) reported that seedhead production was increased on PGR treated plots (compared to a control) where no treatments had been made the second year. PGR induced tiller production increases may be responsible for this observation. Other studies have reported decreased (19,25,29,30,69,72), or no PGR effect (16,75,77,85) on tiller production.

Rhizome production was reported to be decreased (19,29,70,85), or unaffected (29,75,85) by PGR treatment.

PGR Effects on Weed Population

Turf thinning due to PGR phytotoxicity or other plant stress factors can result in reduced turf quality due to weed encroachment (2,11,12, 22,25,57,65,66). Severe color loss in a plot was commonly followed by severe weed infestation which was usually proportional to stand losses (21). Shearing and Batch (61) reported greater weed encroachment on

finer turfs when reduced mowing was practiced and the grass itself was less vigorous due to PGR effects. Several authors recommended that a broad spectrum broadleaf herbicide be incorporated with PGR treatments (2,25,57,64).

One quality of an ideal PGR would be that it provided some suppression of broadleaf weeds in addition to turf suppression. Early (17) reported that PP-333 showed suppression of several monocot and dicot weeds. Embark was reported to suppress (65,66) or have no effect (25) on vegetative and reproductive growth of broadleaf weeds.

PGR Effects on Disease Incidence

Where grass growth is not limited by artificial or environmental stress, turf density and appearance remain reasonably constant over time. Healthy turf can somewhat resist disease infestation and if the turf does become diseased, new healthy blades quickly replace those which were damaged. PGRs inhibit the recuperative ability of grass plants (65,66,76). Depending on the nature of the PGR compound, the grass species treated and the specific disease encountered, the severity of injury can be anywhere from insignificant to catastrophic. Generally, however, PGR treated turfs are more susceptible to disease infestation (53,72). MH treated turfs had greater incidence of disease (15,21,22). Leafspot and red thread injury were more severe on PGR treated turfs (2,15,58,81). Sawyer and Wakefield (58) reported that the severity of red thread infestation on PGR treated Rhode Island roadside plots was related to the date of application with the earliest treated plots having the greatest disease incidence.

Color Enhancement

Schott et al. (60) reported that no color enhancement effects were observed for their studies using Embark applied on several different dates.

Youngner and Nudge (85) reported that treated plants were more intensely green. Their hypothesis was that the PGRs had resulted in increased chlorophyll concentration within the plant. The number of studies reporting color enhancement (2,5,6,19,11,13,27,28,29,43,51,61,65,71) by far exceeds those here none (60) was observed. Other studies showed that after a period of initial discoloration, treated plots developed green color superior to that of the check (8,12,25,47,72,74,77,79,84). Jagschitz (42) found color enhancement on PGR treated plots but noted that it did not last through the balance of the season.

Discoloration or Injury

Turf discoloration is a very common side effect of PGR treatment at any turfgrass maintenance level (61 of 85 cited articles mention this phenomenon specifically). Several authors reported that PGR rates sufficient to provide suppression also caused turf injury or discoloration (5,9,18,21,23,49,39,52,60,70,74,77,78,79).

There are two primary forms of discoloration caused by PGR treatments. First, direct phytotoxic response or disruption of normal green growth, specifically, yellowing of grass blades, tip burn and tip die back, purpling of grass blades, bleached white necrosis and contorted growth of grass blades (2,3,14,19,22,23,24,32,36,37,38,40,41,42,43,46,47,50,53,55,57,61,65,66,67,72,73,75,80,81,82,85). Second,

accumulation of dead or dying tissue caused by natural aging, disease infestation, physical and/or environmental stress (21,22,28,53,65,66,76). Severe long lasting injury was more the exception than the rule (12,13,25,59,69,70,72,84). Watschke (71) reported less discoloration of warm season grasses when compared to cool season varieties. The timing of the PGR application was also reported to influence the severity of discoloration (6,16,49). Nitrogen fertilization helped to reduce the injury from PGR treatment but often counteracted growth suppression effects (13,54).

Descriptions of typical injury or discoloration symptoms were as follows; MH produced a whitish cast to the grass blades (84) or yellowing of vegetation (38); Chlorflurenol, produced a whitish cast to the leaves (13,14), gave the grass a greyish hue (3), resulted in tip burn (84) or bleaching (79); Embark gave the turf a dull green-blue cast (33), resulted in tip burn (55), or browning (80); Sustar caused yellowing (13) or bleaching (79); EL-500 produced leaf tip die-back (37,77), leaf tip yellowing (77) and overall yellowing (37); PP-333 caused leaf tip yellowing to tip die-back (77) and tip burn (50).

Post Inhibition Growth Stimulation

Closely related to color enhancement (discussed previously) is the phenomenon of post inhibition growth situation. Initial discoloration often gave way to color enhancement over time and along with improved color came accelerated growth once the PGR effects dissipated (11,16, 25,29,47,51,52,55,57,61,70,71,74, 75,76,77,78,79,80). Nitrogen fertilization further accelerated post inhibition stimulation (12,80). The period of growth stimulation was relatively short and lasted no more

than five to six weeks before returning to the approximate growth rate of the control (61,76).

Watschke (73) reported that total nonstructural carbohydrates increased with PGR treated plants Kaufmann concurred in a popular article (47). The theory stated that this stored form of energy (TNC) becomes suddenly available once growth suppression has ended, thus resulting in the observed flush of growth.

The Duration of Primary and Secondary PGR Effects

Inhibition of plant vegetation and root growth, discoloration, and seedhead suppression are primary PGR effects. Turf thinning, disease infestation, weed encroachment and shifting of the botanical composition occur as a result of primary effects and are therefore secondary effects.

Eight to twelve weeks of growth suppression would be desired for economic reasons (47). However, a very long residual period would not be considered desirable because of the potential for greater turf injury and environmental hazard (27). Unfortunately the duration of PGR effects varies widely with the prevailing climatic conditions during the period of regulation (47) and by the dates of application (66). The rate of application was also shown to be related to the longevity of inhibitive effects (36,61,77).

Foliarly absorbed PGRs typically take effect more quickly than crown and/or root absorbed compounds, but the latter tended to give more long lasting growth suppression (11). Primary PGR effects were reported to last for as little as four weeks for Sustar and Embark (both foliarly absorbed) and up to thirteen weeks for Cutless (EL-500) to over four

months for PP-333 (2,24,25,41,45,52,59,65,70,71,74,75,79,81). Discoloration was generally short lived (59). Secondary PGR effects can be much longer lasting (up to several years) even though the damage can be done in one season or less as is the case for turf thinning, disease infestation and weed encroachment (11,25,80). Repeated application of PGRs was reported to result in alteration of the botanical composition of the treated sward (23,83). Grass and weed component percentages will change in response to PGR treatment. Willis (83) reported that a PGR treated stand of turf reverted back to its original composition three to four years after treatments were stopped.

Stress Effects and Recuperative Potential of PGR Treated Turfs

Beard (2) wrote "turfs must possess the capability to recuperate from injury caused by adversities". Under specific circumstances PGR treatments might improve the stress tolerance of turf, in particular, the capability to withstand water stress (11,32,45). PGR treated turfs have been shown to have a reduced water use rate due to suppressed vegetative growth where root growth is not adversely affected (47). Hagman (32) suggested that inhibition of Poa annua seedhead production resulted in the redirection of plant metabolites to produce greater rooting or energy storage so that when severe summer stress begins, the plant is more suited to withstand it. However, several investigators concluded that PGRs adversely affected the recuperative potential of turfgrass due to combined inhibition of vegetative and root growth (11,25,47,65,66,76). This leads to turf thinning, increased disease susceptibility and weed encroachment (2,25,47,66,76). Resistance to physical injury (i.e. traffic, mowing, insect and rodent feeding) is

also reduced.

Some PGRs have been shown to dramatically reduce plant growth rates while others will completely stop turf growth (65). PGRs which allow very slow growth also allow some recuperative processes to be maintained during the period of growth suppression.

Retreatment will provide a longer duration of PGR effects, but the turf should be allowed an opportunity to grow prior to the second (or third) PGR application. This is necessary for turf revitalization and stress tolerance enhancement before chemical suppression is once again imposed (77). The post inhibition growth stimulation effect discussed earlier may be advantageous due to the accelerated turf quality enhancement (55).

MATERIALS AND METHODS

This project was entitled "Using Plant Growth Regulators to Develop a Cost Efficient Management System for Roadside Vegetation". Project funding was granted through the Michigan Department of Transportation in cooperation with the Federal Department of Transportation. The PGR compounds used for these investigations were supplied by the chemical manufacturers at no charge. The compounds used were: Embark^R (Mefluidide) and MRB-18337 experimental, 3M Agricultural Products Co.; Cutless^R (Flurprimidol) (EL-500), Eli Lilly and Company; Eptam^R (EPTC), Stauffer Chemical Company; Limit^R (Amidochlor), Monsanto Agricultural Products Co.; PP-333, ICI Americas Inc.; and Telar^R (Chlorsulfuron), The DuPont Company (see Appendix, Table 68 for more information). Specific weather information for each treatment date for all three years of study is found in Appendix, Table 67.

PGR Application Timing Study (DT1) 1982, 1983, 1984

This study was designed to determine the "window of activity" of Mefluidide and Amidochlor on a mixed stand of roadside grass species at a typical highway roadside site.

The study was initiated in 1982 and replicated in 1983 and 1984. A new site was chosen each year. The 1982 site (1DT1) was a highway median strip adjacent to the south bound lanes of US-127 approximately

two miles north of Lake Lansing Road, north of Lansing, Michigan. The predominant grasses were Kentucky bluegrass (Poa pratensis) and fine fescue (Fine Festuca spp.) with some smooth brome grass (Bromus inermis). Soil test results were: pH of 7.8; 34 lb/A P; 116 lb/A K; 6578 lb/A Ca; and 240 lb/A Mg. The soil texture was sandy clay loam. Each plot measured 3.1 meters wide by 21.3 meters long. The plots were separated by a 52.5 cm strip mowed between and around the individual plots and the blocks. These mowed boundaries were maintained at a height of about five cm throughout the summer by regular mowing with a mulching type power mower. This provided convenient walkways for plot rating and provided a very distinct border between plots which was helpful for spotting differences due to treatments and for photographing typical responses. No other mowing was performed.

The 1983 site (2DT1) was an east facing slope on a highway median strip adjacent to the north bound lanes of US-127 just south of State Road, north of Lansing, Michigan. Kentucky bluegrass and smooth brome grass were the predominant species present. Soil test results were: pH of 7.0; 72 lb/A P; 192 lb/A K; 2720 lb/A Ca; and 343 lb/A Mg. The soil texture was clay loam. Each plot measured 3.1 meters wide by 7.6 meters long. The plots were marked with mowed boundaries as described for 1DT1. All plots were mowed with a Toro 52 deck mower at a height of 10.2 cm, 21 Apr, 1983, one day before the first treatment was applied.

The 1984 site (3DT1) was a highway median strip adjacent to the south bound lane of US-127 one half mile north of Lake Lansing Road. The predominant species present were Kentucky bluegrass and fine fescue with some tall fescue (Festuca arundinaceae) and smooth brome grass.

Soil test results were: pH of 7.9; 61 lb/A P; 124 lb/A K; 5440 lb/A Ca; and 300 lb/A Mg. The soil texture was sandy clay loam. Plots were the same size as for 2DT1, and were marked with mowed boundaries as described previously. The entire plot area was mowed by the highway department in the fall of 1983 using a standard tractor with a pto driven deck rotary mower cutting at 10 to 15 cm.

Two PGR compounds were used in these three studies: Mefluidide and Amidochlor. Treatment rates in kilograms active ingredient per hectare (kg/ha) were as follows: For 1982, Mefluidide at 0.22 kg/ha and Amidochlor at 2.2 kg/ha; for 1983 and 1984, Mefluidide at 0.28 kg/ha and Amidochlor at 2.2 kg/ha. All treatments were mixed to volume with water and applied at a rate of 187.0 liters per hectare (l/ha) using a CO₂ plot sprayer equipped with a single flood jet tip (TeeJet 1/4 K-10).

A randomized block design was used with four replications. The two PGR treatments were applied on four dates with one control plot. Treatment dates were: for 1982, 27 Apr, 10 May, 25 May, and 17 June; for 1983, 22 Apr, 4 May, 15 May, and 27 May; and for 1984, 25 Apr, 6 May, 12 May, and 24 May.

Several evaluation parameters were used to judge the results of these studies. Table 1 depicts the evaluations performed for each year of study.

Table 1. Evaluation parameters for 1DT1, 2DT1 and 3DT1.

	1982	1983	1984
Quality of control	-	X	X
Vegetative density	-	X	X
Relative seedhead density	X	X	X
Average seedhead height	-	X	X
Clipping yields	-	X	X
Visual color quality	X	X	-
Relative spring green up	-	X	-
Average vegetative height	X	-	-

Ratings for quality of control were visually scored from 1 to 9 with 9 being considered ideal control. High scores were given to plots where seedhead control was excellent, little injury or discoloration occurred, good turf density was maintained and the turf color was green. Vegetative density was visually scored, the plots with the greatest turf density received the highest scores. Relative seedhead density was visually scored, again on the 1 to 9 scale. A score of 9 would mean heavy seedhead production on a plot; thus a low score would be considered best. Seedhead height was obtained by randomly selecting eight seedheads per species evaluated and measuring their height with a standard meter stick. The eight values were then averaged and the average values were used for data analysis. Where less than eight seedheads were located the average height was calculated from those available, if less than four seedheads were found on a given plot the average was reported as 1.0. Clipping yields were collected with a 21 inch rotary power mower equipped with a clipping collection bag. In 1983 one yield was taken (1 July), in 1984 clipping yields were evaluated on two dates (27 June and 7 Aug). Plots were mowed at 7.9 cm with clippings collected from one swath across the short axis of each plot (3.1 meters). The clippings were then dried 50°C in a forced air oven for at least 24 hours.

Visual color quality was visually scored on the 1 to 9 scale with a score of 9 given for a dark green color without discoloration or injury and no dead or brown grass blades. A score of 1 was given when the turf was dead or completely brown. Relative spring green up is a visual evaluation similar to visual color quality with higher values being given to the plots where normal green up was observed. Low scores were

given to plots where it was apparent that the PGR treatment was inhibiting greenup. As the spring days gradually grow warmer the grass gradually begins to grow and green up. This evaluation was an attempt to identify such responses. Vegetative heights were obtained by measuring the turf canopy height at eight randomly selected spots within each plot using a meter stick. The average of these eight values was then calculated and used for data analysis.

PGR-Herbicide Experimental Application Timing Study (DT1B) 1984

This study was designed to determine the "window of activity" of Mefluidide plus Chlorsulfuron and Amidochlor plus Chlorsulfuron on roadside grass species in a mixed stand at a typical highway roadside site.

This investigation was conducted during 1984. The study site was located on a shallow sloping highway median strip adjacent to the north bound lanes of US-127 approximately one and one half miles north of Lake Lansing Road. Kentucky bluegrass and fine fescue were the predominant grasses. Soil test results were: pH of 8.0; 29 lb/A P; 124 lb/A K; 4560 lb/A Ca; and 287 lb/A Mg. The soil texture was sandy clay loam. Each plot measured 3.1 meters wide by 7.6 meters long and were marked with mowed boundaries as described for DT1 studies (page 38). The entire plot area was mowed in fall 1983 by the highway department the same as described in 3DT1.

In this study two PGR compounds were used in combination with a broad spectrum herbicide. Chlorsulfuron is a powerful broad spectrum systemic herbicide labeled for utility or non-use turf areas. It has very good activity at low rates and is somewhat persistent in the soil,

it has also been shown to produce mutually synergistic effects when combined with Mefluidide. A wetting agent was also added to improve the droplet spreading on the leaf.

Treatment rates in kilograms active ingredient per hectare (kg/ha) were as follows: Mefluidide at 0.14 kg/ha combined with Chlorsulfuron at 0.035 kg/ha and Amidochlor 1.68 kg/ha combined with Chlorsulfuron at 0.035 kg/ha. One half percent (1.17 l/ha) Hydro-Wet nonionic wetting agent was applied with each treatment combination. All treatments were mixed to volume with water and applied by the same method as described for DT1 studies.

A randomized block design with four replications was used. The two PGR-herbicide combinations were applied on five dates with one control plot. The five treatments dates were 20 Apr, 2 May, 10 May, 17 May, and 31 May, 1984.

Parameters evaluated for this study were quality of control, vegetative density, relative seedhead density, average seedhead height, and clipping yields as described for DT1 studies (pages 40 and 41).

Roadside PGR Compound Evaluation Study (DT2) 1982, 1983, 1984

This study was designed to compare the relative effectiveness of seven PGR compounds at recommended application rates. Additionally, the effects of consecutive annual treatments were observed.

The first year of study was 1982. One half of the plots in the original study were retreated in both 1983 and 1984. The same site was used for all three seasons of the investigation. All plots were located on the shoulder and backslope adjacent to US-127 north bound one quarter mile south of State Road, north of Lansing, Michigan. The predominant

grasses were Kentucky bluegrass and fine fescue with some tall fescue, orchardgrass (Dactylis glomerata), redtop (Agrostis alba), and quackgrass (Agropyron repens). Soil test results were: pH of 7.5; 70 lb/A P; 107 lb/A K; 4000 lb/A Ca; and 227 lb/A Mg. The soil texture was sandy clay loam. Each plot measured 3.1 meters wide by 15.2 meters long. The plots were marked with mowed boundaries as described in study 1DT1 (page 35). The plots were mowed at 10-14 cm by the highway department during the fall of 1981. The entire plot area was mowed with a Toro 52 deck mower to a height of 10.2 cm on 5 May, 1983, one day prior to treatment and 7 May, 1984 three days prior to treatment.

Seven PGR compounds were used in the 1982 study: Mefluidide, Amidochlor, Flurprimidol, EPTC, PP-333, MBR-18337 and Chlorsulfuron. Due to the lack of response from MBR-18337 and Chlorsulfuron treatments in 1982, these products were not included in 1983 and 1984 evaluations.

Treatment rates in kilograms active ingredient per hectare (kg/ha) were as follows: Mefluidide at 0.14 kg/ha; Amidochlor at 2.2 kg/ha; Flurprimidol at 1.68 kg/ha; EPTC at 6.7 kg/ha; PP-333 at 1.68 kg/ha; MBR-18337 at 0.14 kg/ha; and Chlorsulfuron at 0.14 kg/ha. All treatments except EPTC were mixed to volume with water and applied the CO₂ plot sprayer as described for DT1 studies (page 39). EPTC is a granular product which was applied with a 1.52 meter Gandy drop spreader.

Treatments were applied 8 May, 1982; 6 May, 1983; and 10 May, 1984. A randomized block design with four replications was used. In 1982 each treatment was duplicated so that in 1983 one set could be left untreated for comparison and evaluation of residual effects.

Several evaluation parameters were used to judge the results of

these studies. Table 2 gives the parameters evaluated by year.

Table 2. Evaluation parameters for DT2, 1982-1984. The method of evaluation for each of these parameters is the same as those described for DT1 studies (pages 40 and 41).

	1982	1983	1984
Quality of control	-	X	X
Vegetative density	-	X	X
Relative seedhead density	X	X	X
Average seedhead height	X	X	X
Clipping yields	-	-	X
Visual color quality	X	X	-
Relative spring green-up	-	X	-
Average vegetative height	X	-	-

PGR Fall Application Timing Study (DT3) 1982

This study was designed to compare the "window of activity" for fall applications of PGRs to similar timing studies conducted in the spring. Also, fall applications of Mefluidide, Amidochlor and PP-333 were to be evaluated for overall effectiveness the following spring.

This study was initiated Fall, 1982. Observations were made the following spring. The study was located on a highway median strip adjacent to the north bound lanes of US-127 approximately one half mile south of State Road, north of Lansing, MI. Soil test results were: pH of 7.6; 58 lb/A P; 98 lb/A K; 3760 lb/A Ca; and 233 lb/A Mg. The soil texture was sandy clay loam. Each plot measured 3.1 meters wide by 7.6 meters long and were marked with mowed boundaries as described for the DT1 studies (page 38). All plots were mowed at a height of 10.2 cm using a Toro 52 deck mower 16 Oct, 1982, two days before the first treatment.

Three PGR compounds were used in this study: Mefluidide, Amidochlor and PP-333. Treatment rates were: Mefluidide at 0.21 kg/ha;

Amidochlor at 2.2 kg/ha; and PP-333 at 1.68 kg/ha. All treatments were mixed to volume with water and applied by the same method as described for DT1 studies (page 39). The four treatment dates were 16 Oct, 25 Oct, 16 Nov, and 1 Dec, 1982.

Parameters evaluated for this study were quality of control, vegetative density, relative seedhead density and relative spring green-up. The method of evaluation for each of these parameters is the same as those described for DT1 studies (page 40 and 41).

PGR Compound-Species Interaction Study (DT4) 1983, 1984

This study was designed to evaluate the relative effectiveness of several PGR compounds on individual roadside grass species growing in a monostand.

Monostand blocks of eight Michigan roadside grass species were established from seed in June 1982 at the Hancock Turfgrass Research Center located on the campus at Michigan State University. The eight grasses seeded in June 1982 are described in Table 3.

Table 3. Grass species in monstand blocks for DT4 studies.

Number	Grass species		Cultivar
	Common Name	Scientific name	
1DT4	Smooth brome grass	<u>Bromus inermis</u>	V-9
2DT4	Kentucky bluegrass	<u>Poa pratensis</u>	Common
3DT4	Orchardgrass	<u>Dactylis glomerata</u>	Potomac
4DT4	Timothy	<u>Phleum pratense</u>	Common
5DT4	Red fescue	<u>Festuca rubra</u>	Pennlawn
6DT4	Perennial ryegrass	<u>Lolium perenne</u>	Common
7DT4	Tall fescue	<u>Festuca arundinaceae</u>	K-31
8DT4	Redtop	<u>Agrostis alba</u>	Common

Difficulties arose when seeding the blocks. Heavy rains after seeding and some slope on the site caused the seed to be washed across the plots resulting in mixed stands. After each of the wash outs the seed was allowed to germinate, then treated with Roundup followed by a subsequent seeding. The third attempt gave successful establishment. The tall fescue and red fescue seedings had been inadvertently reversed resulting in a mixture of these two species for block 5DT4 which was supposed to be red fescue alone. The tall fescue block (7DT4) was not affected by this mixup and matured as a monostand. The entire plot area was fertilized with ammonium nitrate at a rate of 48.8 kg/ha in late August, 1982 to improve the turf density and vigor of the new seedings. Because of problems with broadleaf and grassy weeds in the plots in 1982, Dacthal 5-G was applied at 11.0 kg/ha on 5 Apr, 1983.

Soil test results were: pH of 7.3; 173 lb/A P; 280 lb/A K; 4480 lb/A Ca; and 547 lb/A Mg. The soil texture was sandy clay loam. The species blocks measured 8.2 meters by 9.1 meters with individual plots of 1.4 by 1.5 meters. The blocks were oriented two wide by four long with the long axis running north to south. All plots were mowed at 10.2 cm on 8 May, 1983 nine days before treatment. For 1984 all plots were mowed 10 May, five days before treatment.

Five PGR compounds at two rates each, one PGR-herbicide combination and one control were used for each individual species block study for DT4. The compounds and single combination were as follows: Mefluidide, Amidochlor, Flurprimidol, EPTC, PP-333 and Mefluidide combined with Chlorsulfuron. Hydro-wet, a nonionic wetting agent was mixed with all treatments applied as a liquid.

Treatments were applied as follows: Mefluidide at 0.28 and 0.42

kg/ha; Amidochlor at 1.68 and 2.8 kg/ha; Flurprimidol at 1.12 and 2.2 kg/ha; EPTC at 5.6 and 11.2 kg/ha; PP-333 at 1.12 and 2.2 kg/ha and Mefluidide at 0.14 kg/ha combined with Chlorsulfuron at 0.035 kg/ha. Hydro-wet nonionic wetting agent was added to each liquid treatment (1.17 l/ha) and control plots were sprayed with water and wetting agent. All treatments except EPTC were mixed to volume with water and applied at a rate of 537 liters per hectare using a CO₂ mini boom plot sprayer. The 1983 treatments were made with a boom which had two Tee Jet^R even flat spray tips (size 8003-E). 1984 treatments were made with a boom which had four regular flat fan spray tips (size 8002).

All liquid applications were made 17 and 18 May, 1983 and 15 May, 1984. Dry application of EPTC was made 20 May, 1983 and 16 May, 1984. All eight species blocks were set up as individual studies. Within each species block, a randomized block design with three replications was used.

Several evaluation parameters were used to evaluate the results of these studies. Table 4 lists the evaluations made for study DT4 in 1983 and 1984.

Table 4. Evaluation parameters for all DT4 studies, 1983 and 1984.

	1983	1984
Quality of control	X	X
Vegetative density	-	X
Relative seedhead density	X	X
Average seedhead height	X	X
Visual color quality	X	-
Relative discoloration/injury	X	X
Actual vegetative height	X	-

Quality of control, vegetative density, relative seedhead density, and

visual color quality are parameters evaluated exactly the same as described in DT1 studies (pages 40 and 41). Average seedhead height and actual vegetative height measurements were changed slightly from the DT1 description. Rather than the average of eight values used in DT1, six measurements were used to calculate the average value for data analysis in the DT4 studies. Where less than six seedheads were located on a plot, the average height was calculated from those available, if less than three seedheads were found the average was reported as 1.0. Relative discoloration (injury) was a visual rating for the relative severity of phytotoxicity produced by a PGR treatment. Scoring was on the 1 to 9 scale where 9 was given for little or no discoloration. A score of 1 indicated severe injury. Relative seedhead height was only reported for 1983. This parameter was a visual evaluation of mean seedhead height on a 1 to 9 scale where 9 indicated the tallest seedheads within a species block. A value of 1 was given if the seedheads were not taller than the turf canopy or if seedhead production had been completely inhibited and no seedheads were visible. Actual measurements of seedhead heights were seen as more useful for response evaluation.

Mowing Energy Study (DT5) 1983, 1984

This study was designed to evaluate the potential for the reduction of mowing energy consumption as a result of PGR treatments.

This study was conducted for the 1983 and 1984 seasons. The plots were located at the Soils Research Farm on Hagadorn Road at Michigan State University. The plot area was predominantly Kentucky bluegrass with quackgrass and redtop sparsely spread through two replications and

some broad leaved weeds such as dandelion, curly dock, white clover and wild carrot in all blocks. Soil test results were: pH of 7.1; 104 lb/A P; 116 lb/A K; 3120 lb/A Ca; and 505 lb/A Mg. The soil texture was sandy clay loam. Each plot measured 1.2 meters wide by 9.1 meters long. The entire plot area was mowed at a height of five cm on 8 May, 1983, three days before treatment and 11 May, 1984, three days before treatment. The plots were treated with 2,4-D Amine on 21 May, 1984 at 1.68 kg/ha and 22 June, 1984, with Trimec at 6.2 l/ha.

Two rates of three PGR compounds and one PGR-herbicide combination were applied in this study; Mefluidide at 0.14 and 0.28 kg/ha; Amidochlor at 1.12 and 2.2 kg/ha; EPTC at 5.6 and 11.2 kg/ha; Mefluidide at 0.07 kg/ha combined with Chlorsulfuron at 0.035 kg/ha; and Mefluidide at 0.14 kg/ha combined with Chlorsulfuron at 0.035 kg/ha. One half percent (1.17 l/ha) Hydro-wet nonionic wetting agent was added to each liquid treatment. Control plots were sprayed with water and wetting agent. All treatments except EPTC were mixed to volume with water and applied at a rate of 187.0 liters per hectare in 1983 and 211 l/ha in 1984. A CO₂ mini boom plot sprayer with two TeeJet 8002 spray tips was used to apply liquid treatments in 1983 and in 1984 a different boom with four 8001 tips was used. Granular EPTC was applied with a 1.2 meter Gandy spreader.

Treatments were applied 11 May, 1983 and 14 May, 1984. A randomized block design with four replications was used.

Evaluation parameters used to judge the results of this study are listed in Table 5. The methods of evaluation for quality of control,

Table 5. Evaluation parameters for study DT5 for 1983 and 1984.

	1983	1984
Quality of control	X	X
Vegetative density	X	X
Relative seedhead density	X	X
Visual color quality	X	-
Average vegetative height	X	-
Relative vegetative growth	X	-
Weed population index	X	X
Watts used	X	X

vegetative density, relative seedhead density, visual color quality, and average vegetative height are the same as those described for DT4 studies (page 48). Relative vegetative growth was visually evaluated and scored on the 1 to 9 basis with a score of 9 given to plots with the greatest vegetative growth. A weed population index was made in order to quantify the weed encroachment in occurrence at this study site. Visual ratings were scored from 1 to 9 where a high score represented greater weed populations. Weed species of all types were rated as a whole.

Watts used was a physical measurement of electrical energy used to mow a specific plot area with a modified electric rotary mower. A Sears 45.7 cm double bladed electric rotary mower was used. The mower was pushed at a constant rate of travel for thirteen seconds over two mower widths on each plot. The energy used for these thirteen second trials was recorded with a standard watt hour meter ($Kh = 3.6$) which had been specially modified for this project. A jump connection between the field magnet coils was installed with a switch which permitted stopping and starting the meter wheel for each thirteen second reading. The wheel was set to zero for each plot and the switch turned off. The mower was then switched on and allowed to come to speed. Forward travel

began as the meter wheel was switched on. At thirteen seconds, the meter wheel was switched off and the value corresponding to the number of revolutions recorded. One revolution would yield a reading of 100. The values of both runs on each plot were added together then multiplied by the Kh (3.6) to give watts used, which was the value used for data analysis. The mower was started before and stopped after the thirteen second mowing trials. The extra power needed to start the mower and the electrically activated motor brake were not considered to be energy demands related to turf density, vegetative height and seedhead production, which are the factors considered to have the most influence on the energy demand for mowing.

PGR Rate and Mixture Study (DT6) 1983, 1984

This study was designed to determine the effectiveness of several PGRs and PGR-herbicide combinations at different rates on roadside grass species on a mixed stand at a typical roadside site. The same study site was used in 1983 and 1984 and was located on a slightly sloping highway median strip adjacent to the south bound lanes of US-127 approximately one half mile south the of the US-127 to US-27 interchange. The predominant grasses on this site were Kentucky bluegrass, fine fescue, and quackgrass. Soil test results were: pH of 7.6; 40 lb/A P; 133 lb/A K; 6240 lb/A Ca; and 488 lb/A Mg. The soil texture was sandy clay loam. Each plot measured 3.1 meters wide by 7.6 meters long. These plots were marked with mowed boundaries as described in DT1 studies. The plot area was mowed with a Toro 52 deck mower to a height of 10.2 cm on 5 May, 1983, four days before treatment and 10 May, 1984, one day before treatment.

Two rates of five PGR compounds and two PGR-Herbicide combinations were used in this study: Mefluidide at 0.28 and 0.42 kg/ha; Amidochlor at 1.12 and 2.2 kg/ha; Flurprimidol at 1.12 and 2.2 kg/ha; EPTC at 5.6 and 11.2 kg/ha; PP-333 at 1.12 and 2.2 kg/ha; Mefluidide at 0.07 kg/ha combined with Chlorsulfuron at 0.035 kg/ha; Mefluidide at 0.14 kg/ha combined with Chlorsulfuron at 0.035 kg/ha; Amidochlor at 0.84 kg/ha combined with Chlorsulfuron at 0.035 kg/ha and Amidochlor at 1.68 kg/ha combined with Chlorsulfuron at 0.035 kg/ha. Hydro-wet nonionic wetting agent was added to all liquid treatments at one half percent (1.17 l/ha). All treatments except EPTC were mixed to volume with water and applied by the methods described in DT1 studies (page 39).

Treatments were applied 9 May, 1983, and 5 May, 1984. A randomized block design with four replications was used.

Evaluation parameters used to judge the results of this study are given in Table 6.

Table 6. Evaluation parameters for study DT6 for 1983 and 1984. The methods for all six evaluations are the same as those described for DT1 studies (pages 40 and 41).

	1983	1984
Quality of control	X	X
Vegetative density	X	X
Relative seedhead density	X	X
Average seedhead height	X	X
Visual color quality	X	-
Clipping yields	X	X

Simulated Highway Roadside PGR Application Study (DT7) 1984

This study was designed to evaluate the efficacy of selected PGR-herbicide combinations on roadside grass and weed species in a mixed stand on an existing highway roadside site when applied by simulated highway application methods.

This study was done in 1984. The study site was located on a highway roadside shoulder adjacent to the north bound lanes of US-127 approximately one and one-half miles north of Cedar Street, south of Lansing, MI. Predominant grasses on this site were Kentucky bluegrass and fine fescue with some smooth brome grass, orchardgrass and tall fescue randomly mixed throughout. Soil test results were: pH of 8.0; 20 lb/A P; 107 lb/A K; 4240 lb/A Ca; and 160 lb/A Mg. The soil texture was sandy clay loam. Each plot measured 30.5 meters long by approximately 7.6 meters deep; the depth was regulated by how far the spray was thrown by the spray rig and on wind effects. Between each plot was a 12.2 meter buffer zone to be used for evaluation comparisons and to separate one plot from another. The entire area had been mowed at 10-14 cm the previous summer by highway department crews using standard highway roadside maintenance methods.

Five PGR-herbicide combinations were used in this study: Amidochlor at 1.68 kg/ha combined with 2,4-D amine at 1.8 kg/ha; Amidochlor at 1.68 kg/ha combined with Chlorsulfuron at 0.035 kg/ha; Amidochlor at 1.68 kg/ha combined with 2,4-D amine at 1.12 kg/ha and Chlorsulfuron at 0.023 kg/ha; Mefluidide at 0.14 kg/ha combined with Chlorsulfuron at 0.035 kg/ha; and Mefluidide at 0.14 kg/ha combined with 2,4-D amine at 1.12 kg/ha and Chlorsulfuron at 0.023 kg/ha. Hydro-wet nonionic wetting agent was added to each treatment at one quarter percent by volume (0.58 l/ha).

All treatments were mixed to volume with water and applied with two nozzles attached to a boom built and configured to simulate a MDOT spray rig. One high boom was installed at about 2.6 meters from ground level and 1.5 meters out from the side of spray rig. A second boom was

mounted even with the side of the vehicle at about 1.5 meters from ground level. Spray pattern of about 7.6 meters in width was provided by this configuration when the lower tip was tilted to properly adjust the spray pattern for overlap. The simulated spray rig was driven at approximately 15.5 miles per hour (25 km/hr) to apply the spray volume of 479 l/ha.

All treatments were applied 16 May, 1984. A randomized block design with three replications was used.

Evaluation parameters used for this study were quality of control, vegetative density, and relative seedhead density as described for DT1 studies (pages 40 and 41). The method of evaluation for weed population index ratings was described in study DT5 (page 50).

All studies were analyzed using Duncan's New Multiple Range Test at the 5 percent level of significance. Data means within columns with like letters do not differ significantly according to this method.

RESULTS AND DISCUSSION

PGR Application Timing Study DT1

This study was conducted over three growing seasons. Treatments commenced in the early spring once the grass had begun to grow. The earliest treatments were applied during the last ten days of April all three years. Treatments were spaced ten days to two weeks apart depending on the weather conditions at the scheduled time of spraying.

Overall quality of control ratings were established to evaluate the broad range visual aesthetic quality of the turf as affected by the PGR treatments. This evaluation parameter was not based on any one quality or aspect of PGR effects. The individual features which contributed to this "overall" sort of rating included vegetative density, vegetative color, percent seedhead suppression, seedhead height, and species specificity of the PGRs tested.

1982 1DT1

Relative seedhead density ratings were taken 30 July, 1982 (Table 7). Significant reductions in seedhead density resulted from Mefluidide and Amidochlor treatments for the first two dates of application, 27 Apr and 10 May. The 25 May applications gave no significant reduction while the 17 June application of both compounds statistically increased seedhead production compared to the control. No seedhead height

Table 7. 1DT1 PGR Application Timing Study-1982. Relative seedhead density all species combined. Visual estimates, 1 to 9 where 9 = greatest seedhead density. Evaluated 30 July, 1982.

Treatment		Date of Application	Relative seedhead density
Chemical	Rate (kg/ha)		
Control	-	-	4.9 bc*
Mefluidide	0.22	27 Apr	2.1 d
Mefluidide	0.22	10 May	2.3 d
Mefluidide	0.22	25 May	5.6 ab
Mefluidide	0.22	17 June	5.9 a
Amidochlor	2.2	27 Apr	1.6 d
Amidochlor	2.2	10 May	2.5 d
Amidochlor	2.2	25 May	4.0 c
Amidochlor	2.2	17 June	5.9 a
Standard Error			0.3

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

measurements, clipping yield or quality of control ratings were taken in 1982.

Visual color quality was rated on two dates (Table 8). Color enhancement for both compounds resulted from the first and second application dates. Color enhancement was observed by 23 of 85 authors cited for the literature review (see page 32). Amidochlor applied 27 Apr gave the greatest color enhancement of all treatments. Although this color enhancement was very noticeable and was considered to be improved over the control, the appearance should not be perceived as that of a high quality turf.

Vegetative height reductions were measured on several dates after treatment (Table 9). It should be noted that while statistical significance was found, the differences were small and the practical benefits from such responses are limited. Most grass vegetation found in utility turf situations grows to some height where vegetative lodging takes place. Once this happens, it is no longer important to what length the grass blades grow. For this reason managers of utility grass sites seldom need to focus closely on vegetative suppression with PGRs.

1983 2DT1

Quality of control ratings were taken on two dates in 1983 (Table 10). 14 June evaluations showed significant improvements in overall turf quality from the first and third applications of Mefluidide and the third application of Amidochlor. The magnitude of the improvement is not, however, sufficient to be judged beneficial from a practical standpoint. Four weeks later (18 July) quality ratings for all treated plots were statistically different than the control. On this date,

Table 8. IDT1 PGR Application Timing Study-1982. Visual color quality, visual estimates 1 to 9 where 1 = yellow and 9 = dark green.

Treatment	Rate	Date of Application	Color quality	
			Date of evaluation	
Chemical	(kg/ha)		30 July 82	23 Aug 82
Control	-	-	3.5 d*	4.4 d*
Mefluidide	0.22	27 Apr	4.3 cd	5.0 c
Mefluidide	0.22	10 May	4.8 bc	5.3 c
Mefluidide	0.22	25 May	4.0 cd	4.5 d
Mefluidide	0.22	17 June	3.8 cd	4.3 d
Amidochlor	2.2	27 Apr	6.3 a	6.3 a
Amidochlor	2.2	10 May	5.5 ab	5.8 b
Amidochlor	2.2	25 May	4.3 cd	4.6 d
Amidochlor	2.2	17 June	3.8 cd	4.4 d
Standard Error			0.3	0.1

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 9. 1DT1 PGR Application Timing Study-1982. Vegetative height in cm. 8 subsamples taken per plot per date.

Treatment			Vegetative height			
Chemical	Rate	Date of Application	Dates of evaluation			
			20 May	28 July	30 Aug	4 Nov
	(kg/ha)		(cm)	(cm)	(cm)	(cm)
Control	-	-	21.2 ab*	30.1 a*	28.5 a*	26.6 a*
Mefluidide	0.22	27 Apr	20.1 ac	30.1 a	27.4 ab	24.4 bc
Mefluidide	0.22	10 May	20.7 ac	29.0 ab	28.7 a	25.5 ab
Mefluidide	0.22	25 May	19.9 ac	27.2 bc	25.3 bc	24.2 bc
Mefluidide	0.22	17 June	18.7 c	28.5 ac	26.7 ab	23.3 cd
Amidochlor	2.2	27 Apr	18.8 c	24.2 de	23.1 c	21.7 de
Amidochlor	2.2	10 May	19.0 bc	23.3 e	22.5 c	21.7 de
Amidochlor	2.2	25 May	21.0 ac	26.2 cd	23.5 c	21.3 e
Amidochlor	2.2	17 June	21.5 a	29.6 ab	26.5 ab	24.1 bc
Standard Error			0.7	0.8	0.9	0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 10. 2DT1 and 3DT1 PGR Application Timing Study-1983 and 1984. Quality of control combining all factors. Visual estimates, 1 to 9 where 9 = ideal control.

Treatment	Chemical	Rate (kg/ha)	Quality of control						
			Dates of Application		Dates of evaluation				
			1983	1984	1983		1984		
					14 June	18 July	30 May	25 June	20 July
Control	-	-	-	-	3.5 c*	2.8 c*	3.0 c*	2.0 d*	1.0 f*
Mefluidide	0.28	22 Apr	25 Apr		5.1 ab	5.4 ab	6.6 a	7.0 ab	6.6 b
Mefluidide	0.28	4 May	6 May		4.3 bc	6.5 a	6.5 a	5.6 bc	5.8 c
Mefluidide	0.28	15 May	12 May		5.8 a	5.6 ab	4.5 b	4.5 c	3.4 d
Mefluidide	0.28	27 May	24 May		4.4 bc	4.3 b	3.0 d	2.3 d	1.8 ef
Amidochlor	2.2	22 Apr	25 Apr		4.4 bc	6.4 a	7.0 a	7.3 ab	6.6 b
Amidochlor	2.2	4 May	6 May		3.6 c	6.1 a	7.3 a	8.3 a	8.0 a
Amidochlor	2.2	15 May	12 May		4.9 ab	5.4 ab	6.5 a	7.9 a	7.3 ab
Amidochlor	2.2	27 May	24 May		4.4 bc	4.4 b	3.1 c	2.3 d	2.3 de
Standard Error					0.3	0.4	0.4	0.6	0.4

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

practical improvements were observed from the second Mefluidide application and the first two treatments of Amidochlor. However, highest ranking plots would not be comparable in quality to mechanically mowed turf. These results were judged to be satisfactory for most highway roadside areas. Turf density was statistically reduced on all dates for both PGR compounds (Table 11). Despite this, none of the plots were considered to be unsatisfactory for practical purposes because the real differences were small.

Relative seedhead density (Table 12) was dramatically reduced at both dates of evaluation in 1983 by the second Mefluidide application and the first two Amidochlor applications. The practical significance of this response was considered to be very strong. Response from all other dates of application for both compounds was inadequate from a practical standpoint. The "window of activity" for 1983 clearly ended somewhere between the 4 May and 15 May application dates.

Bromegrass seedhead production (Table 13) was completely inhibited by the third Amidochlor treatment and the second and third Mefluidide treatments. It is interesting to note the apparent discrepancy for seedhead suppression when comparing Table 12 (relative seedhead density) to Table 13 (bromegrass seedhead height). For example, compare the 15 May results for the Amidochlor treatments; bromegrass seedhead production had been almost completely inhibited, yet the relative seedhead density ratings were moderately high. This clearly shows that seedhead production by the other grasses had not been significantly reduced.

This illustrates an important point. Utility grass areas are normally very diverse in their botanical composition (61). Furthermore,

Table 11. 2DT1 and 3DT1 PGR Application Timing Study-1983 and 1984.
Vegetative density all species combined. Visual estimates,
1 to 9 where 9 = greatest vegetative density.

<u>Treatment</u>		<u>Dates of application</u>		<u>Vegetative density</u>		
				<u>Dates of evaluation</u>		
<u>Chemical</u>	<u>Rate</u> (kg/ha)			<u>1983</u>	<u>1984</u>	
				<u>18 July</u>	<u>30 May</u>	<u>25 June</u>
Control	-	-	-	6.8 a*	8.0 a*	8.0 a*
Mefluidide	0.28	22 Apr	25 Apr	6.1 b	5.0 f	7.5 b
Mefluidide	0.28	4 May	6 May	5.5 bc	6.6 d	6.5 d
Mefluidide	0.28	15 May	12 May	5.6 b	7.4 b	7.0 c
Mefluidide	0.28	27 May	24 May	6.0 b	7.9 a	7.6 b
Amidochlor	2.2	22 Apr	25 Apr	5.6 b	6.1 e	7.3 bc
Amidochlor	2.2	4 May	6 May	4.9 c	6.9 cd	6.6 d
Amidochlor	2.2	15 May	12 May	5.4 bc	7.0 c	7.0 c
Amidochlor	2.2	27 May	24 May	6.1 b	7.9 a	7.5 b
Standard Error				0.2	0.1	0.1

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 12. 2DT1 and 3DT1 PCR Application Timing Study-1983 and 1984. Relative seedhead density all species combined. Visual estimates, 1 to 9 where 9 = greatest seedhead density.

Treatment	Rate (kg/ha)	Dates of Application		Relative seedhead density		
				Dates of evaluation		
				1983		1984
Chemical		1983	1984	14 June	18 July	20 July
Control	-			6.5 a*	7.0 a*	9.0 a*
Mefluidide	0.28	22 Apr	25 Apr	4.3 bc	4.0 c	3.5 c
Mefluidide	0.28	4 May	6 May	2.0 d	2.1 d	5.4 b
Mefluidide	0.28	15 May	12 May	3.5 bd	5.0 bc	8.0 a
Mefluidide	0.28	27 May	24 May	5.1 ab	6.6 a	8.3 a
Amidochlor	2.2	22 Apr	25 Apr	2.9 cd	1.9 d	2.9 cd
Amidochlor	2.2	4 May	6 May	2.1 d	1.4 d	1.5 d
Amidochlor	2.2	15 May	12 May	4.9 ab	5.8 ab	4.5 bc
Amidochlor	2.2	27 May	24 May	6.8 a	6.8 a	7.9 a
Standard Error				0.6	0.5	0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 13. ZDT1 PGR Application Timing Study-1983. Bromegrass seedhead heights in cm. 8 subsamples per plot. Evaluated 22 July, 1983.

Treatment Chemical	Rate (kg/ha)	Date of Application	Bromegrass seedhead height (cm)
Control	-	-	86.3 a*
Mefluidide	0.28	22 Apr	60.8 ab
Mefluidide	0.28	4 May	1.0 c
Mefluidide	0.28	15 May	1.0 c
Mefluidide	0.28	27 May	56.0 ab
Amidochlor	2.2	22 Apr	75.1 ab
Amidochlor	2.2	4 May	38.0 bc
Amidochlor	2.2	15 May	1.0 c
Amidochlor	2.2	27 May	53.5 ab
Standard Error			12.4

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

each grass species is physiologically different and the plant mechanisms responsible for seedhead production are also different. Therefore, due to the diversity of species found on a typical roadside and the consequent differences among them, it is reasonable to assume that a particular date of PGR application might be ideal for the effective seedhead suppression of one species while being entirely inappropriate for all the other species of that sward. This is precisely the response observed for study 2DT1 in 1983. The specific suppression of brome grass seedhead production was excellent for the second and third dates of application, while the relative seedhead density ratings were only moderate to good for those same two dates. This whole set of circumstances is descriptively termed "species specific response". Elkins et al. (22) noted similar variation among species with identical treatments. One quality of an ideal PGR would be the lack of species specific response (25,47,61,65).

Seedhead heights for Kentucky bluegrass were reduced by all treatments in 1983 (Table 14). The second Mefluidide treatment and the first two Amido chlor treatments completely inhibited seedhead production. Height reductions for other treatments ranged from 17 percent for the final Amido chlor treatments to 59 percent for the first application of Mefluidide when compared to the control.

Clipping yields were taken 1 July, 1983. Most treatments reduced clipping yields but not all reductions were statistically significant compared to the control (Table 15). Yield reductions for the second and third application dates of Mefluidide and Amido chlor were significant from both a statistical and practical standpoint. Species variability among plots contributed to the lack of sensitivity in the statistical

Table 14. 2DT1 and 3DT1 PCR Application Timing Study-1983 and 1984. Kentucky Bluegrass seedhead heights in cm. 8 subsamples per plot.

<u>Treatment</u>		<u>Dates of Application</u>		<u>Seedhead heights</u> <u>Dates of evaluation</u>	
Chemical	Rate	1983	1984	1983 22 July	1984 20 July
	(kg/ha)			(cm)	(cm)
Control	-	-	-	53.5 a*	55.2 a*
Mefluidide	0.28	22 Apr	25 Apr	21.9 d	27.2 c
Mefluidide	0.28	4 May	6 May	1.0 e**	27.7 c
Mefluidide	0.28	15 May	12 May	30.5 cd	38.3 b
Mefluidide	0.28	27 May	24 May	39.9 bc	43.5 b
Amidochlor	2.2	22 Apr	25 Apr	1.0 e	25.4 cd
Amidochlor	2.2	4 May	6 May	1.0 e	20.3 d
Amidochlor	2.2	15 May	12 May	36.7 bc	22.2 cd
Amidochlor	2.2	27 May	24 May	44.5 ab	42.0 b
Standard Error				4.1	1.9

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

** Where less than eight seedheads were located the average height was calculated from those available, if less than four seedheads were found on a given plot the average was reported as 1.0.

Table 15. 2DT1 and 3DT1 PGR Application Timing Study-1983 and 1984. Dry weight of clipping yields mowed at 8.9 cm.

Treatment	Rate	Dates of Application		Dates of evaluation		
		1983	1984	1983 1 July	1984 27 June	1984 7 August
Chemical	(kg/ha)			(gm)	(gm)	(gm)
Control	-	-	-	248 ab*	260 a*	242 a*
Mefluidide	0.28	22 Apr	25 Apr	210 ac	173 be	130 bd
Mefluidide	0.28	4 May	6 May	103 d	146 de	150 bd
Mefluidide	0.28	15 May	12 May	135 cd	225 ad	195 ac
Mefluidide	0.28	27 May	24 May	173 ad	251 ab	208 ab
Amidochlor	2.2	22 Apr	25 Apr	165 bd	155 ce	138 bd
Amidochlor	2.2	4 May	6 May	112 d	140 e	96 d
Amidochlor	2.2	15 May	12 May	111 d	123 e	121 cd
Amidochlor	2.2	27 May	24 May	256 a	233 ac	187 ac
Standard Error				28.0	26.0	25.0

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

analysis.

Visual color quality for 2DT1, 1983 is reported in Table 16. The greatest color enhancement was found for the first two Amidochlor treatments. Spring green-up evaluations showed that both Mefluidide and Amidochlor applied at the two earliest dates had adversely affected normal grass green-up (Table 17). Link et al. (50) found that early spring PGR treatments produced an inferior appearance because new spring growth was inhibited and therefore could not hide the accumulation of dead tissue from the previous year.

1984 3DT1

All plots were rated for quality of control on three dates in 1984. The early summer drought which began the end of May and lasted well into July had a dramatic effect on the responses from the PGR treatments. Field and Whitford (25) stated that dry conditions drastically reduced the difference in growth from control plot vs. treated plots. The quality ratings for the control plots declined over time (Table 10) primarily due to prolific seed production and the negative visual effects associated with seed production. On 30 May, 1984 the quality of control for the first three application dates was significantly superior to the control. For the 25 June and 20 July evaluations the first two Mefluidide treatments received superior quality scores and the first three Amidochlor treatments maintained their quality rating improvements. The final application of both compounds resulted in poor turf quality, similar to that of the control. The 25 Apr treatments resulted in the greatest vegetative density reductions for both compounds when evaluated 30 May (Table 11). By the 25 June evaluation

Table 16. 2DT1 PCR Application Timing Study-1983. Visual color quality, visual estimates 1 to 9 where 1 = yellow and 9 = dark green. Evaluated 18 July, 1983.

Treatment Chemical	Rate (kg/ha)	Date of Application	Color quality
Control	-	-	5.3 de*
Mefluidide	0.28	22 Apr	5.8 bc
Mefluidide	0.28	4 May	6.1 b
Mefluidide	0.28	15 May	5.3 de
Mefluidide	0.28	27 May	5.4 d
Amidochlor	2.2	22 Apr	6.6 a
Amidochlor	2.2	4 May	6.6 a
Amidochlor	2.2	15 May	5.0 e
Amidochlor	2.2	27 May	5.5 cd
Standard Error			0.1

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 17. 2DT1 PGR Application Timing Study-1983. Visual estimates of spring green-up, vegetative color and density combined, 1 to 9 where 9 = best looking turf. Evaluated 20 May, 1983.

Treatment	Date of Application		Spring green-up
Chemical	Rate (kg/ha)		
Control	-	-	6.9 a*
Mefluidide	0.28	22 Apr	5.5 b
Mefluidide	0.28	4 May	5.6 b
Mefluidide	0.28	15 May	6.8 a
Mefluidide	0.28	27 May	6.9 a
Amidochlor	2.2	22 Apr	5.1 b
Amidochlor	2.2	4 May	5.4 b
Amidochlor	2.2	15 May	6.9 a
Amidochlor	2.2	27 May	7.1 a
Standard Error			0.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

those plots had recovered to an acceptable level.

Relative seedhead density ratings were lowest for the first Mefluidide treatments and for the first and second Amidochlor treatments (Table 12). Other differences were not considered to have practical significance, although our analysis showed statistical significance for some. Kentucky bluegrass seedhead heights were reduced from 22 to 64 percent in 1984 (Table 14), although these results were not as marked as in 1983. Even though five of the eight treatments resulted in seedhead height reductions of at least 50 percent, the practical significance is limited. The three earliest Amidochlor applications in 1984 completely inhibited the seedhead production of fine fescue (Table 18). All other treatments had no effect on fine fescue seedhead height compared to the check.

The first two applications of Mefluidide and the first three applications of Amidochlor each gave significant clipping yield reductions for both dates of evaluation in 1984 (Table 15). Because all clipping reductions were 40 percent or more, these five treatments can be considered beneficial from a practical standpoint. The effects of the other three treatments were not significantly different from the control.

PGR-Herbicide Experimental Application Timing Study DT1B

Table 19 gives quality of control ratings for DT1B in 1984, taken on three dates. The 10 May, 1984 Mefluidide-Chlorsulfuron treatments produced moderate turf quality ratings at all three dates of evaluation. Turf quality ratings for the 2 May and 10 May Amidochlor-Chlorsulfuron treatments were given moderate scores on 30 May and steadily improved up

Table 18. 3DT1 PGR Application Timing Study-1984. Fine Fescue seedhead heights in cm. 8 subsamples per plot. Evaluated 20 July, 1984.

Treatment Chemical	Rate	Date of application	Fine fescue seedhead height
	(kg/ha)		(cm)
Control	-	-	42.8 a*
Mefluidide	0.28	25 Apr	38.8 a
Mefluidide	0.28	6 May	35.8 a
Mefluidide	0.28	12 May	28.0 a
Mefluidide	0.28	24 May	33.5 a
Amidochlor	2.2	25 Apr	1.0 b
Amidochlor	2.2	6 May	1.0 b
Amidochlor	2.2	12 May	1.0 b
Amidochlor	2.2	24 May	30.0 a
Standard Error			5.1

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 19. DT1B PGR-Herbicide Experimental Application Timing Study-1984.
Quality of control combining all factors. Visual estimates,
1 to 9 where 9 = ideal control.

Treatment		Date of Application	Quality of control		
Chemical	Rate (kg/ha)		30 May 84	25 June 84	24 July 84
Control	-	-	5.3 ac*	3.0 d*	1.0 f*
Mefluidide + Chlorsulfuron	0.14 0.035	20 Apr	4.4 c	5.3 ab	3.8 e
Mefluidide + Chlorsulfuron	0.14 0.035	2 May	4.5 bc	5.4 ab	5.5 bd
Mefluidide + Chlorsulfuron	0.14 0.035	10 May	5.6 a	5.6 ab	5.4 be
Mefluidide + Chlorsulfuron	0.14 0.035	17 May	5.5 ab	6.5 a	4.8 ce
Mefluidide + Chlorsulfuron	0.14 0.035	31 May	5.5 ab	5.9 ab	4.1 de
Amidochlor + Chlorsulfuron	1.68 0.035	20 Apr	2.0 d	5.0 bc	5.8 bc
Amidochlor + Chlorsulfuron	1.68 0.035	2 May	4.5 bc	5.3 ab	6.6 ab
Amidochlor + Chlorsulfuron	1.68 0.035	10 May	5.1 ac	6.6 a	7.5 a
Amidochlor + Chlorsulfuron	1.68 0.035	17 May	5.8 a	5.8 ab	5.6 bd
Amidochlor + Chlorsulfuron	1.68 0.035	31 May	5.5 ac	3.8 cd	2.0 f
Standard Error			0.3	0.4	0.5

* Means within columns with like letters do not differ significantly
according to Duncan's Multiple Range Test (5%).

to the final evaluation, 24 July, 1984. Turf color is an important component in these quality ratings, several authors (8,12,25, 47,72,74,77,79,84) reported that treated plots developed superior green color after a period of initial discoloration. The quality ratings for the control plots were highest at the 30 May rating date and declined sharply thereafter as seedhead production reached its peak. Quality ratings generally improved to a peak score, then leveled off or slightly decreased over time. Quality ratings of the three earliest Amidochlor-Chlorsulfuron treatments peaked on the final evaluation date. The poorest responses were found with the 31 May applications of both PGR-herbicide combinations. These data suggest that the best PGR effects can be generated by applications during or before the second week of May. Seasonal weather variations will affect the recommended application times for optimum PGR efficacy.

Vegetative density was reduced by all treatment combinations applied before the 30 May evaluation date (Table 20). Some density reductions were severe, particularly those recorded for the earliest dates of application. Several of the plots with the most severe turf thinning had recovered to an acceptable level by the 25 June evaluation.

Relative seedhead density ratings showed the most effective seedhead suppression was provided by the four earliest Amidochlor-Chlorsulfuron treatments (Table 21). The 31 May application date was clearly too late to provide good seedhead suppression. All Mefluidide-Chlorsulfuron combinations reduced relative seedhead density statistically, but not by a practically significant amount. Both compound combinations at all dates of application reduced the height of the Kentucky bluegrass and fine fescue seedheads which were produced

Table 20. DT1B PGR-Herbicide Experimental Application Timing Study-1984.
Vegetative density all species combined. Visual estimates,
1 to 9 where 9 = greatest vegetative density.

Treatment Chemical	Rate (kg/ha)	Date of Application	Vegetative density	
			30 May 84	25 June 84
Control	-	-	7.4 a*	8.9 a*
Mefluidide + Chlorsulfuron	0.14 0.035	20 Apr	2.5 f	6.0 e
Mefluidide + Chlorsulfuron	0.14 0.035	2 May	3.3 ef	6.6 ce
Mefluidide + Chlorsulfuron	0.14 0.035	10 May	4.0 de	6.5 ce
Mefluidide + Chlorsulfuron	0.14 0.035	17 May	5.1 bc	7.1 c
Mefluidide + Chlorsulfuron	0.14 0.035	31 May	7.0 a	8.0 b
Amidochlor + Chlorsulfuron	1.68 0.035	20 Apr	1.1g	4.9 f
Amidochlor + Chlorsulfuron	1.68 0.035	2 May	2.8 f	5.1 f
Amidochlor + Chlorsulfuron	1.68 0.035	10 May	4.3 cd	6.3 de
Amidochlor + Chlorsulfuron	1.68 0.035	17 May	5.5 b	6.8 cd
Amidochlor + Chlorsulfuron	1.68 0.035	31 May	6.9 a	8.4 ab
Standard Error			0.3	0.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 21. DT1B PGR-Herbicide Experimental Application Timing Study-1984.
Relative seedhead density of species combined. Visual estimates,
1 to 9 where 9 = greatest seedhead density. Evaluated 24 July, 1984.

Treatment Chemical	Rate (kg/ha)	Date of Application	Relative seedhead density
Control	-	-	9.0 a*
Mefluidide	0.14	20 Apr	6.6 bc
+ Chlorsulfuron	0.035		
Mefluidide	0.14	2 May	5.6 cd
+ Chlorsulfuron	0.035		
Mefluidide	0.14	10 May	4.5 de
+ Chlorsulfuron	0.035		
Mefluidide	0.14	17 May	5.3 ce
+ Chlorsulfuron	0.035		
Mefluidide	0.14	31 May	6.4 bd
+ Chlorsulfuron	0.035		
Amidochlor	1.68	20 Apr	3.5 ef
+ Chlorsulfuron	0.035		
Amidochlor	1.68	2 May	2.5 f
+ Chlorsulfuron	0.035		
Amidochlor	1.68	10 May	2.4 f
+ Chlorsulfuron	0.035		
Amidochlor	1.68	17 May	4.5 de
+ Chlorsulfuron	0.035		
Amidochlor	1.68	31 May	8.1 ab
+ Chlorsulfuron	0.035		
Standard Error			0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multipole Range Test (5%).

regardless of PGR effects (Table 22). The greatest height reductions for bluegrass seedheads were produced by Mefluidide-Chlorsulfuron treatments applied 2 and 10 May. Amidochlor-Chlorsulfuron treatments gave good but less dramatic reductions for the same application dates. Both treatment combinations performed poorest at the earliest (20 Apr) and latest (31 May) dates of application. Reductions in seedhead height of fine fescue were not affected by date of application over the duration of treatments applied.

Clipping yields were highly variable on 27 June which is why the statistical separation of these results is poor (Table 23). The Mefluidide-Chlorsulfuron treatments made on 2 and 10 May gave satisfactory yield reductions on 27 June. The first, second and fourth treatment dates were superior for Amidochlor-Chlorsulfuron treatments evaluated 27 June. The 10 May Amidochlor-Chlorsulfuron application was essentially ineffective on both dates of evaluation. Greater yield reductions were found at the 7 Aug for nearly all compounds and for most dates of application. Clipping yields for 31 May, Mefluidide-Chlorsulfuron treatments and 10 May, Amidochlor-Chlorsulfuron treatments were not statistically different from the control. This inconsistency may be partially explained by the fact that 1.32 cm of rain was recorded on 13 May three days after treatments (see Table 67 in the appendix for rainfall data). Thus, it should be noted that the Mefluidide-Chlorsulfuron had ample time to be foliarly absorbed which resulted in good growth suppression while the Amidochlor-Chlorsulfuron treatments had not yet been washed into the crown and root zone of the soil where it could be absorbed and affect plant growth. This hypothesis is further supported by the good growth reduction recorded

Table 22. DT1B PGR-Herbicide Experimental Application Timing Study-1984.
Seedhead height in cm for Kentucky bluegrass and fine fescue,
8 subsamples per plot. Measurements taken 24 July, 1984.

Treatment Chemical	Rate (kg/ha)	Date of Application	Seedhead heights	
			Kentucky bluegrass (cm)	fine fescue (cm)
Control	-	-	43.9 a*	46.6 a*
Mefluidide	0.14	20 Apr	33.3 b	29.6 b
+ Chlorsulfuron	0.035			
Mefluidide	0.14	2 May	13.1 e	26.7 b
+ Chlorsulfuron	0.035			
Mefluidide	0.14	10 May	4.4 f	29.1 b
+ Chlorsulfuron	0.035			
Mefluidide	0.14	17 May	20.6 de	26.0 b
+ Chlorsulfuron	0.035			
Mefluidide	0.14	31 May	30.1 bc	28.4 b
+ Chlorsulfuron	0.035			
Amidochlor	1.68	20 Apr	30.2 bc	26.7 b
+ Chlorsulfuron	0.035			
Amidochlor	1.68	2 May	21.6 ce	23.0 b
+ Chlorsulfuron	0.035			
Amidochlor	1.68	10 May	18.0 de	23.2 b
+ Chlorsulfuron	0.035			
Amidochlor	1.68	17 May	22.2 cd	23.0 b
+ Chlorsulfuron	0.035			
Amidochlor	1.68	31 May	33.8 b	28.7 b
+ Chlorsulfuron	0.035			
Standard Error			2.8	2.3

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 23. DT1B PGR-Herbicide Experimental Application Timing Study-1984.
Dry weight of clipping yields mowed at 8.9 cm.

Treatment		Date of Application	Dry weight of clipping yields	
Chemical	Rate		Dates of evaluation	
	(kg/ha)		27 June 84 (gm)	7 Aug 84 (gm)
Control	-	-	127 a*	114 a*
Mefluidide + Chlorsulfuron	0.14 0.035	20 Apr	115 ab	54 b
Mefluidide + Chlorsulfuron	0.14 0.035	2 May	82 ab	76 b
Mefluidide + Chlorsulfuron	0.14 0.035	10 May	86 ab	59 b
Mefluidide + Chlorsulfuron	0.14 0.035	17 May	114 ab	56 b
Mefluidide + Chlorsulfuron	0.14 0.035	31 May	124 a	88 ab
Amidochlor + Chlorsulfuron	1.68 0.035	20 Apr	74 ab	79 b
Amidochlor + Chlorsulfuron	1.68 0.035	2 May	54 b	74 b
Amidochlor + Chlorsulfuron	1.68 0.035	10 May	115 ab	87 ab
Amidochlor + Chlorsulfuron	1.68 0.035	17 May	76 ab	66 b
Amidochlor + Chlorsulfuron	1.68 0.035	31 May	97 ab	66 b
Standard Error			19.0	10.0

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

for the 17 May Amidochlor-Chlorsulfuron treatments which received rain the following day.

The severity of phytotoxicity on tall fescue appeared to be related to the physiological stage of growth at the time of treatment. Duell et al. (16) reported that injury to perennial ryegrass from MH treatments was more severe on earlier treated plots. General observations found that the earliest dates of application caused greater turf injury and delayed spring green-up more dramatically than later treatments. Chlorsulfuron was previously observed to be somewhat phytotoxic to tall fescue on other plots in earlier years.

Roadside PGR Compound Evaluation Study DT2

The 1DT2, 1982 studies were planned with eight replications. This was done with the intention of treating only four replicates the following season. The remaining untreated plots were then evaluated for residual effects from the first year treatments.

1982 1DT2

Relative seedhead density ratings showed that EPTC and Amidochlor treatments were very effective in the suppression of seedhead production (Table 24). Seedhead heights were measured for Kentucky bluegrass, fine fescue, redtop and quackgrass in 1982 (Table 25). Significant and practical height reductions were recorded with EPTC and Amidochlor treatments on Kentucky bluegrass only. Seedhead height reductions occurred with these and other compounds for fine fescue but the reductions were inadequate from a practical standpoint. Redtop and quackgrass seedhead production was essentially unaffected by PGR

Table 24. 1DT2, 2DT2 and 3DT2 Roadside PGR Compound Evaluation Study-1982, 1983, and 1984. Relative seedhead density all species combined. Visual estimates, 1 to 9 where 9 = greatest seedhead density. Treatment descriptions with a prefix of 1 were treated 8 May, 1982 only. A prefix of 2 indicates plots treated 8 May, 1982, 6 May, 1983 and 10 May, 1984.

Treatment		Relative seedhead density Dates of evaluation			
Chemical	Rate (kg/ha)	1982 30 July	1983 14 June	1983 19 July	1984 19 July
Control	-	6.0 ac*	6.3 ae*	6.1 ab*	8.1 a*
1-Flurprimidol	1.68	6.3 ab	5.6 bf	6.5 ab	**
2-Flurprimidol	1.68	6.5 ab	5.1 ef	6.1 ab	6.9 a
1-Mefluidide	0.14	4.8 cd	5.4 df	6.0 ab	-
2-Mefluidide	0.14	4.0 d	4.8 f	5.9 b	6.0 a
1-EPTC	6.7	1.4 e	6.8 ac	7.4 a	-
2-EPTC	6.7	1.4 e	2.0 g	1.8 c	2.8 b
1-Chlorsulfuron	0.14	6.5 ab	6.8 ac	6.9 ab	-
2-Chlorsulfuron	0.14	6.5 ab	5.5 cf	6.5 ab	-
1-MBR-18337	0.14	5.6 ac	6.9 ab	6.8 ab	-
2-MBR-18337	0.14	5.5 bc	6.6 ad	6.9 ab	-
1-Amidochlor	2.2	1.8 e	6.3 ae	7.0 ab	-
2-Amidochlor	2.2	1.6 e	2.3 g	2.3 c	1.9 b
1-PP-333	1.68	6.6 ab	7.5 a	7.3 ab	-
2-PP-333	1.68	6.9 a	6.1 bf	6.8 ab	6.1 a
Standard Error		0.4	0.4	0.4	0.7

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

** no treatment applied to these plots, therefore no data value is reported.

Table 25. 1DT2 Roadside PGR Compound Evaluation Study-1982. Seedhead height in cm for Kentucky bluegrass, fine fescue, redtop and quackgrass. 8 subsamples per plot. Treatment descriptions with a prefix of 1 or 2 were treated alike in 1982, the treatment date was 8 May, 1982. Evaluated 10 Sept, 1982.

Treatment		Seedhead height			
Chemical	Rate (kg/ha)	Kentucky bluegrass (cm)	fine fescue (cm)	redtop (cm)	quackgrass (cm)
Control	-	43.3 a*	51.1 ab*	57.6 a*	67.4 ab*
1-Flurprimidol	1.68	32.4 ad	45.2 ae	58.0 a	65.1 ab
2-Flurprimidol	1.68	33.6 ad	40.2 cg	59.8 a	62.2 ab
1-Mefluidide	0.14	26.8 ce	48.6 ac	53.5 ab	68.0 ab
2-Mefluidide	0.14	31.1 bd	51.0 ab	58.9 a	69.3 ab
1-EPTC	6.7	15.1 f	35.6 fg	51.8 ab	61.9 ab
2-EPTC	6.7	17.3 ef	37.4 eg	54.3 ab	61.0 b
1-Chlorsulfuron	0.14	38.9 ab	44.2 bf	57.0 a	64.3 ab
2-Chlorsulfuron	0.14	35.2 ac	46.5 ad	51.7 ab	59.6 b
1-MBR-18337	0.14	30.7 bd	46.0 ae	57.1 a	66.1 ab
2-MBR-18337	0.14	36.0 ac	53.2 a	59.8 a	74.0 a
1-Amidochlor	2.2	29.1 bd	43.2 bg	56.9 a	60.4 b
2-Amidochlor	2.2	22.9 df	35.0 g	54.8 ab	61.1 b
1-PP-333	1.68	23.7 df	35.7 fg	47.2 b	62.0 ab
2-PP-333	1.68	30.3 bd	39.5 dg	57.9 a	57.5 b
Standard Error		3.4	2.7	2.7	3.8

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

treatment for this study.

Visual color quality was improved by EPTC and Amidochlor applications when evaluated at twelve and sixteen weeks after treatment (Table 26). Statistically significant vegetative height reductions on several grasses were recorded for some PGR treatments in 1982 (Table 27). However, the magnitude of the vegetative suppression for this study was not sufficient to provide practical benefit. As previously stated, once the grass leaves have reached a height where lodging occurs, it makes no difference to what length they grow.

1983 2DT2

Overall quality of control ratings showed that there were essentially no carry over effects from the 1982 treatments and that the 1983 quality ratings improved over time (Table 28). Dernoeden (11) reported that carry-over effects from yearly PGR treatments were significantly negative for Kentucky bluegrass plots treated with ethephon and mefluidide in the previous two years. Again, EPTC and Amidochlor received the best scores. The improvement between the 14 June and 19 July evaluation date is most likely the result of some new growth being produced which in effect masked some of the old senescent tissue and any phytotoxic injury which the compound might have caused initially. Turf density reductions as compared to the control ranged from no difference to significantly but not severely reduced (Table 29).

No residual effects on 1983 seedhead production were seen from 1982 treatments. EPTC and Amidochlor gave the greatest seedhead suppression for 1983 (Tables 24 and 30) at both dates of evaluation. EPTC produced almost complete inhibition of seedhead production for Kentucky bluegrass

Table 26. 1DT2 and 2DT2 Roadside PGR Compound Evaluation Study-1982 and 1983. Visual color quality, 1 to 9 where 1 = yellow and 9 = dark green. Treatment descriptions with a prefix of 1 were treated 8 May, 1982 only. A prefix of 2 indicates plots treated 8 May, 1982 and 6 May, 1983.

Treatment		Color quality		
Chemical	Rate (kg/ha)	Dates of evaluation		
		30 July 82	27 Aug 82	19 July 83
Control	-	5.0 ef*	4.4 d*	6.0 bc*
1-Flurprimidol	1.68	4.8 f	4.5d	6.3 b
2-Flurprimidol	1.68	5.1 ef	4.4d	6.0 bc
1-Mefluidide	0.14	5.6 ce	4.9 cd	6.8 b
2-Mefluidide	0.14	6.0 c	5.3 c	6.8 b
1-EPTC	6.7	7.4 ab	6.6 ab	6.5 ab
2-EPTC	6.7	7.6 a	6.8 a	7.8 a
1-Chlorsulfuron	0.14	5.3 dg	4.4 d	6.0 bc
2-Chlorsulfuron	0.14	5.3 df	4.8 cd	5.1 c
1-MBR-18337	0.14	5.5 ce	4.9 cd	6.3 b
2-MBR-18337	0.14	5.8 cd	5.0 cd	6.3 b
1-Amidochlor	2.2	6.9 b	6.3 ab	6.5 b
2-Amidochlor	2.2	7.0 ab	6.0 b	7.9 a
1-PP-333	1.68	4.6 f	4.5 d	5.8 bc
2-PP-333	1.68	4.6 f	4.8 cd	6.0 bc
Standard Error		0.2	0.2	0.3

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 27. 1DT2 Roadside Compound Evaluation Study-1982. Vegetative height in cm. 8 subsamples taken per plot per date. Treatment descriptions with a prefix of 1 or 2 were treated alike in 1982, the treatment date was 8 May, 1982.

Treatment Chemical	Rate	Vegetative Height			
		19 May 82	16 July 82	25 Aug 82	2 Nov 82
	(kg/ha)	(cm)	(cm)	(cm)	(cm)
Control	-	26.0 ab	35.2 a*	33.7 ab*	31.1 ab*
1-Flurprimidol	1.68	26.0 ab	31.1 ad	29.5 bd	25.6 e
2-Flurprimidol	1.68	25.5 ab	28.6 ce	28.7 ce	27.1 ce
1-Mefluidide	0.14	26.4 a	34.1 ab	34.5 a	33.4 a
2-Mefluidide	0.14	26.1 ab	33.2 ac	32.1 ad	28.8 be
1-EPTC	6.7	22.7 d	25.0 e	28.4 de	26.5 de
2-EPTC	6.7	22.5 d	25.3 e	27.9 de	26.2 de
1-Chlorsulfuron	0.14	24.2 bd	30.9 ad	31.9 ad	31.4 ab
2-Chlorsulfuron	0.14	23.4 cd	27.6 de	28.1 de	26.9 ce
1-MBR-18337	0.14	24.9 ac	33.6 ab	33.0 ac	31.4 ab
2-MBR-18337	0.14	25.6 ab	33.1 ac	34.1 a	31.3 ab
1-Amidochlor	2.2	25.6 ab	30.3 bd	30.5 ad	30.6 ac
2-Amidochlor	2.2	24.8 ac	29.9 bd	32.0 ad	30.0 ad
1-PP-333	1.68	24.9 ac	25.3 e	22.5 f	21.0 f
2-PP-333	1.68	26.4 a	28.1 de	25.2 ef	25.5 e
Standard Error		0.6	1.4	1.3	1.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 28. 2DT2 and 3DT2 Roadside PGR Compound Evaluation Study-1983 and 1984. Quality of control combining all factors. Visual estimates, 1 to 9 where 9 = ideal control. Treatment descriptions with a prefix of 1 were treated 8 May, 1982 only. A prefix of 2 indicates plots treated 8 May, 1982, 6 May, 1983 and 10 May, 1984.

Treatment		Quality of control				
		Dates of evaluation				
Chemical	Rate (kg/ha)	1983		1984		
		14 June	19 July	30 May	25 June	19 July
Control	-	1.1 e*	2.4 d*	4.1 c*	3.0 e*	2.9 b*
1-Flurprimidol	1.68	1.8 de	2.8 d	**	-	-
2-Flurprimidol	1.68	3.9 ab	4.5 c	4.8 b	4.4 cd	4.0 b
1-Mefluidide	0.14	1.8 de	2.6 d	-	-	-
2-Mefluidide	0.14	3.1 bc	3.0 d	5.1 b	3.5 de	4.3 b
1-EPTC	6.7	1.3 de	2.0 d	-	-	-
2-EPTC	6.7	3.3 ac	7.1 a	6.3 a	6.1 b	6.9 a
1-Chlorsulfuron	0.14	1.1 e	2.0 d	-	-	-
2-Chlorsulfuron	0.14	2.6 cd	2.9 d	-	-	-
1-MBR-18337	0.14	1.3 de	2.0 d	-	-	-
2-MBR-18337	0.14	1.4 de	2.0 d	-	-	-
1-Amidochlor	2.2	1.3 de	2.0 d	-	-	-
2-Amidochlor	2.2	4.0 ab	6.9 a	6.6 a	7.8 a	8.0 a
1-PP-333	1.68	1.5 de	2.0 d	-	-	-
2-PP-333	1.68	4.5 a	5.6 b	5.1 b	5.4 bc	4.5 b
Standard Error		0.4	0.3	0.2	0.4	0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

** no treatment applied to these plots, therefore, no data value is reported.

Table 29. 2DT2 and 3DT2 Roadside PGR Compound Evaluation Study-1983 and 1984. Vegetative density all species combined. Visual estimates, 1 to 9 where 9 = greatest vegetative density. Treatment descriptions with a prefix of 1 were treated 8 May, 1982 only. A prefix of 2 indicates plots treated 8 May, 1982, 6 May, 1983 and 10 May, 1984.

Treatment		Vegetative density		
		Dates of evaluation		
		1983	1984	
Chemical	Rate	19 July	30 May	25 June
	(kg/ha)			
Control	-	7.1 a*	7.1 a*	8.0 a*
1-Flurprimidol	1.68	7.0 a	**	-
2-Flurprimidol	1.68	6.0 c	6.8 a	7.6 ab
1-Mefluidide	0.14	6.9 a	-	-
2-Mefluidide	0.14	6.8 ab	6.8 a	7.8 ab
1-EPTC	6.7	6.8 ab	-	-
2-EPTC	6.7	6.6 ac	5.8 b	6.5 c
1-Chlorsulfuron	0.14	6.8 ac	-	-
2-Chlorsulfuron	0.14	6.0 c	-	-
1-MBR-18337	0.14	6.8 ab	-	-
2-MBR-18337	0.14	6.9 a	-	-
1-Amidochlor	2.2	7.1 a	-	-
2-Amidochlor	2.2	6.6 ac	6.0 b	6.8 bc
1-PP-333	1.68	6.4 ac	-	-
2-PP-333	1.68	6.1 bc	6.9 a	7.8 ab
Standard Error		0.2	0.2	0.3

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

** no treatment applied to these plots, therefore no data value is reported.

Table 30. 2DT2 and 3DT2 Roadside PGR Compound Evaluation Study-1983 and 1984. Seedhead height in cm for Kentucky bluegrass and fine fescue. 8 subsamples per plot. Treatment descriptions with a prefix of 1 were treated 8 May, 1982 only. A prefix of 2 indicates plots treated 8 May, 1982, 6 May, 1983 and 10 May, 1984.

Treatment		Seedhead heights			
Chemical	Rate (kg/ha)	Kentucky bluegrass		fine fescue	
		26 July 83 (cm)	19 July 84 (cm)	26 July 83 (cm)	19 July 84 (cm)
Control	-	45.9 a*	41.6 a*	53.9 a*	48.7 a*
1-Flurprimidol	1.68	44.3 a*	**	53.1 a	-
2-Flurprimidol	1.68	34.9 bc	31.6 ab	36.6 d	35.2 b
1-Mefluidide	0.14	44.4 a	-	49.5 ab	-
2-Mefluidide	0.14	39.9 ab	19.5 c	48.6 ab	46.4 a
1-EPTC	6.7	45.4 a	-	52.7 ab	-
2-EPTC	6.7	1.0 e	4.9 d	1.0 f	29.0 b
1-Chlorsulfuron	0.14	47.4 e	-	52.8 ab	-
2-Chlorsulfuron	0.14	39.4 ab	-	43.4 c	-
1-MBR-18337	0.14	47.1 a	-	51.0 ab	-
2-MBR-18337	0.14	47.0 a	-	53.5 a	-
1-Amidochlor	2.2	47.5 a	-	52.2 ab	-
2-Amidochlor	2.2	19.3 d	18.8 c	1.0 f	31.3 b
1-PP-333	1.68	44.6 a	-	47.6 bc	-
2-PP-333	1.68	30.9 c	30.5 b	30.2 e	32.8 b
Standard Error		2.6	3.4	1.6	2.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

** no treatment applied to these plots, therefore no data value is reported.

and fine fescue in 1983 (Table 30). Amidochlor drastically reduced bluegrass seedhead height and completely inhibited fine fescue seedhead production in 1983. Other compounds shortened those seedstalks which were produced but overall seedhead suppression effects were limited.

Applications of EPTC and Amidochlor improved the vegetative color quality when rated 10 weeks after treatment (Table 26). All other compounds had no significant effect on color. Spring green-up was rated two weeks after treatments in 1983. EPTC and Amidochlor were observed to be causing the most inhibition of green-up (Table 31), this response was not sufficient to be considered objectionable. All other compounds did not significantly affect green-up and there were no residual effects apparent from the 1982 treatments.

1984 3DT2

Individual observations for certain plots were noted where specific effects were evident. It was noticed that the weed population on Chlorsulfuron plots from 1982 treatments were very much reduced compared to the other plots. Chlorsulfuron at 0.14 kg/ha is considered a heavy application but not greater than the maximum recommended on the label. Repeat applications for 1983 were not made with Chlorsulfuron due to the observed lack of grass growth suppression or seedhead inhibition. This makes our observations particularly interesting because this superior weed control was the result of one application two years earlier. Another observation was that tall fescue appeared to be more severely injured by Chlorsulfuron treatments. Because the tall fescue populations were inconsistent throughout the study area this response could not be statistically analyzed.

Table 31. 2DT2 Roadside PGR Compound Evaluation Study-1983. Visual estimates of spring green-up, vegetative color and density combined. 1 to 9 where 9 = green turf. Treatment descriptions with a prefix of 1 were treated 8 May, 1982 only. A prefix of 2 indicates plots treated 8 May, 1982 and 6 May, 1983. Evaluated 20 May, 1983.

Treatments		Spring green-up
Chemical	Rate (kg/ha)	
Control	-	6.8 ab*
1-Flurprimidol	1.68	6.3 b
2-Flurprimidol	1.68	6.3 b
1-Mefluidide	0.14	6.4 ab
2-Mefluidide	0.14	6.6 ab
1-EPTC	6.7	7.1 a
2-EPTC	6.7	5.5 c
1-Chlorsulfuron	0.14	7.1 a
2-Chlorsulfuron	0.14	6.3 b
1-MBR-18337	0.14	6.8 ab
2-MBR-18337	0.14	6.8 ab
1-Amidochlor	2.2	6.4 ab
2-Amidochlor	2.2	5.5 c
1-PP-333	1.68	7.0 ab
2-PP-333	1.68	6.3 b
Standard Error		0.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Overall quality of control ratings were made three, seven and ten weeks after treatment in 1984 (Table 28). EPTC and Amidochlor treatments provided the best quality of control, and the quality of these plots followed a generally improving trend as the season progressed. All other compounds provided varied degrees of response but these were not considered adequate for practical purposes. EPTC and Amidochlor produced significant vegetative density reductions, however, the reductions by these and all other compounds were not great enough to be considered objectionable (Table 29).

Relative seedhead density was reduced dramatically by EPTC and Amidochlor applications (Table 24). All other compounds did not provide significant seedhead suppression. EPTC was the most effective compound for reducing the height of the seedheads produced by Kentucky bluegrass and fine fescue in 1984 (Table 30). Amidochlor and Mefluidide reduced Kentucky bluegrass seedhead extension by more than half. Amidochlor, PP-333, and Flurprimidol reduced the elongation of fine fescue seedheads but not by a practical amount great enough to justify recommendations for commercial use.

Clipping yields for 1984 were collected from each treated plot and the control at four and eight weeks after treatment (Table 32). Four weeks after treatment no statistically different yields were found. This could be attributed to the species variability among the plots. By 13 July (eight weeks after application the EPTC treatments resulted in yields less than half those of the control plots. Amidochlor reduced yields by about 46 percent for the 13 July harvest. Yields from all other treated plots were not significantly different from the control.

Table 32. 3DT2 Roadside PGR Compound Evaluation Study-1984. Dry weight of clipping yields mowed at 8.9 cm. Treatment descriptions with a prefix of 2 were treated 8 May, 1982, 6 May, 1983 and 10 May, 1984.

<u>Treatment</u>		Dry weight of clipping yields Dates of evaluation	
<u>Chemical</u>	<u>Rate</u> (kg/ha)	11 June, 1984 (gm)	13 July, 1984 (gm)
Control	-	271 a*	388 a*
2-Flurprimidol	1.68	216 a	339 a
2-Mefluidide	0.14	274 a	418 a
2-EPTC	6.7	218 a	173 b
2-Amidochlor	2.2	256 a	207 b
2-PP-333	1.68	258 a	391 a
Standard Error		29.0	35.0

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Fall PGR Application Timing Study DT3

This study was conducted only during 1982. Treatments were applied in late fall 1982 and evaluated the following spring to determine whether there would be any inhibitive effects upon the resumption of spring growth and/or seedhead production from the fall applications.

Quality of control ratings taken 14 June and 18 July, 1983 showed generally poor performance by all compounds at each date of application (Table 33). Foote and Himmelman (26) found poor response from MH applied in the fall while Chappell et al. (9) reported that Sustar produced its best results when applied in the fall. Although statistically significant differences were found, the magnitude of the differences were small and all levels of turf quality were considered to be inadequate.

Vegetative density ratings showed that all PP-333 treatments had thinned the turf as of the 18 July, 1983 evaluation date (Table 34). This thinning was not however, so severe as to be considered objectionable. Amidochlor and Mefluidide treatments did not appear to adversely affect turf density.

Relative seedhead density was essentially unaffected by Mefluidide and Amidochlor treatments. PP-333 plots evaluated 14 June had reduced seedhead production for the first, third, and fourth application dates (Table 35). The magnitude of seedhead reduction for all PP-333 treatments was best for the earlier rating date (14 June). This is due to the fact that seedhead production had not yet reached its peak.

Spring green-up ratings were recorded, 2 May and 20 May, 1983 (Table 36). Normal green-up, similar to the control plots was observed for all plots treated with Mefluidide or Amidochlor. This was the case

Table 33. DT3 Fall PGR Application Timing Study-1982. Quality of control combining all factors. Visual estimates, 1 to 9 where 9 = ideal control.

Treatment Chemical	Rate (kg/ha)	Date of Application	Quality of control	
			14 June 83	18 July 83
Control	-	-	2.1 bc*	3.0 bc*
Mefluidide	0.21	16 Oct	3.1 ab	3.4 ac
Mefluidide	0.21	25 Oct	2.8 ac	3.3 ac
Mefluidide	0.21	16 Nov	2.3 ac	3.4 ac
Mefluidide	0.21	1 Dec	2.6 ac	3.3 ac
Amidochlor	2.2	16 Oct	2.0 c	2.8 c
Amidochlor	2.2	25 Oct	2.1 bc	2.8 c
Amidochlor	2.2	16 Nov	2.5 ac	2.9 c
Amidochlor	2.2	1 Dec	2.4 ac	2.8 c
PP-333	1.68	16 Oct	3.3 a	4.1 a
PP-333	1.68	25 Oct	3.0 ac	3.4 ac
PP-333	1.68	16 Nov	3.1 ab	3.8 ac
PP-333	1.68	1 Dec	3.3 a	4.0 ab
Standard Error			0.3	0.3

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 34. DT3 Fall PGR Application Timing Study-1982. Vegetative density all species combined. Visual estimates, 1 to 9 where 9 = greatest vegetative density. Evaluated 18 July, 1983.

Treatment Chemical	Rate (kg/ha)	Date of Application	Vegetative density
Control	-	-	6.8 a*
Mefluidide	0.21	16 Oct	6.3 ab
Mefluidide	0.21	25 Oct	6.6 a
Mefluidide	0.21	16 Nov	6.4 ab
Mefluidide	0.21	1 Dec	6.6 a
Amidochlor	2.2	16 Oct	6.5 a
Amidochlor	2.2	25 Oct	6.9 a
Amidochlor	2.2	16 Nov	6.6 a
Amidochlor	2.2	1 Dec	6.6 a
PP-333	1.68	16 Oct	5.1 d
PP-333	1.68	25 Oct	5.8 bc
PP-333	1.68	16 Nov	5.8 bc
PP-333	1.68	1 Dec	5.6 cd
Standard Error			0.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 35. DT3 Fall PGR Application Timing Study-1982. Relative seedhead density all species combined. Visual estimates, 1 to 9 where 9 = greatest seedhead density.

Treatment Chemical	Rate (kg/ha)	Date of Application	Relative seedhead density	
			14 June 83	18 July 83
Control	-	-	7.4 a*	6.4ab*
Mefluidide	0.21	16 Oct	5.4 bc	5.4 ab
Mefluidide	0.21	25 Oct	6.5 ab	5.9 ab
Mefluidide	0.21	16 Nov	6.6 ab	5.6 ab
Mefluidide	0.21	1 Dec	6.3 ab	5.0 b
Amidochlor	2.2	16 Oct	7.4 a	6.1 ab
Amidochlor	2.2	25 Oct	7.0 ab	6.9 a
Amidochlor	2.2	16 Nov	7.3 a	6.5 ab
Amidochlor	2.2	1 Dec	7.1 a	6.6 ab
PP-333	1.68	16 Oct	3.8 c	5.8 ab
PP-333	1.68	25 Oct	5.8 ab	7.0 a
PP-333	1.68	16 Nov	4.0 c	6.0 ab
PP-333	1.68	1 Dec	4.0 c	5.4 ab
Standard Error			0.5	0.5

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 36. DT3 Fall PGR Application Timing Study-1982. Visual estimates of spring green-up, vegetative color and density combined. 1 to 9 where 9 = green turf.

<u>Treatment</u>		Date of Application	<u>Spring green-up</u>	
Chemical	Rate (kg/ha)		2 May 83	20 May 83
Control	-	-	6.0 ab*	7.5a*
Mefluidide	0.21	16 Oct	5.9 ab	7.4 a
Mefluidide	0.21	25 Oct	6.4 a	7.6 a
Mefluidide	0.21	16 Nov	5.9 ab	7.3 a
Mefluidide	0.21	1 Dec	5.3 b	7.5 a
Amidochlor	2.2	16 Oct	6.0 ab	7.4 a
Amidochlor	2.2	25 Oct	5.9 ab	7.5 a
Amidochlor	2.2	16 Nov	6.0 ab	7.4 a
Amidochlor	2.2	1 Dec	6.4 a	7.5 a
PP-333	1.68	16 Oct	1.0 d	3.1 c
PP-333	1.68	25 Oct	2.0 c	4.3 b
PP-333	1.68	16 Nov	1.4 cd	3.5 c
PP-333	1.68	1 Dec	1.5 cd	3.6 c
Standard Error			0.3	0.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

for both evaluation dates. PP-333 treated plots were observed to green-up much more slowly than the control. The severely delayed green-up was sufficient to be considered undesirable. Clearly, PP-333 was the most active PGR for fall application in this study. Another observation was the distinct appearance of PP-333 effects beyond the study borders down slope of the actual plot boundary. It was evident that some portion of the applied PP-333 had been displaced down slope, in all probability carried by laterally flowing water.

PGR Compound-Species Interaction Study DT4

Eight monostand grass species blocks were established at the Hancock Turfgrass Research Center in 1982. Treatments were applied in May, 1983 and May, 1984. Each block was treated as an individual study and therefore were accordingly numbered: 1DT4-bromegrass, 2DT4-Kentucky bluegrass, 3DT4-orchardgrass, 4DT4-timothy, 5DT4-fine fescue, 6DT4-perennial ryegrass, 7DT4-tall fescue and 8DT4-redtop.

Three areas of difficulty were encountered through the course of these studies. The original establishment of these plots was delayed when the first two seedings were washed out by rain. After each rain out the seed was allowed to germinate and then sprayed with Roundup herbicide before seeding again. Unfortunately, it was evident that the fine fescue and tall fescue blocks had been switched for the third seeding which resulted in a tall fescue-fine fescue mixture for block 5DT4. The final tall fescue block (7DT4) was unaffected. The columns labelled fine fescue in the data tables actually represent the fine fescue -tall fescue mixture described above. Quality of control, vegetative density, relative seedhead density, visual color quality, and

relative discoloration/injury ratings were evaluated as a whole, for this mixture. The average seedhead height and average vegetative height measurements were taken from the tall fescue component because of its predominance.

A second complication was that the seeding rates for 1DT4-bromegrass, 3DT4-orchardgrass and 7DT4-tall fescue were too high which resulted in above optimum plant density for these coarse grasses. These high plant densities created competition among the individual grass plants and resulted in abnormally low seedhead production even on untreated plots, thus the evaluation of seedhead responses was adversely affected. These three blocks were not ideally representative of utility turf sites but they were treated and evaluated the same as other blocks.

There was some bromegrass contamination of the Kentucky bluegrass plots as a result of the seed establishment difficulties. In addition, the 1983 treatments on Kentucky bluegrass were misapplied. Since there was no alternative 2DT4-Kentucky bluegrass evaluations were not reported.

The third difficulty developed in 1984. An oversight on the part of a fellow researcher resulted in the accidental mowing of twelve plots. This represented one row of six plots or one half of one replication for 1DT4-bromegrass and 2DT4-Kentucky bluegrass, therefore 1984 data were not reported for these studies.

1983 DT4 All Species

Quality of control ratings for 1983 are found in Table 37. Flurprimidol had no influence on any grass and there were no significant effects on orchardgrass by any PGR compound. The only statistical

Table 37. DT4 PGR Compound-Species Interaction Studies-1983. Quality of control combining all factors. Visual estimates, 1 to 9 where 9 = ideal control. Liquid treatments applied 17 May and 18 May, 1983, dry applications made 20 May, 1983. Evaluated 21 July, 1983.

Treatment Chemical	Rate (kg/ha)	Quality of control				
		Bromegrass	Orchard- grass	Timothy	Fine fescue ryegrass	Tall fescue
Control	-	3.5 bc*	5.2 ab*	1.3 c*	2.0 b*	2.2 de* 1.7 d* 1.7 cd*
Flurprimidol	1.12	2.7 bc	5.8 ab	1.0 c	1.3 b	1.7 e 4.0 ad 1.0 d
Flurprimidol	2.2	1.7 c	4.5 b	2.2 bc	2.7 b	1.7 e 3.5 bd 1.3 d
Mefluidide	0.28	5.5 ab	6.0 ab	1.7 bc	1.7 b	3.7 be 2.0 d 2.2 bd
Mefluidide	0.42	7.5 a	5.0 ab	3.0 ac	2.8 b	3.7 be 1.8 d 4.3 a
EPTC	5.6	3.2 bc	5.8 ab	4.0 ab	6.2 a	6.5 ac 5.3 ac 4.0 ac
EPTC	11.2	5.3 ab	4.5 b	4.7 a	5.5 a	7.2 ab 4.7 ac 5.8 a
Amidochlor	1.68	5.5 ab	6.7 a	1.7 bc	6.2 a	7.5 a 6.3 a 4.3 ac
Amidochlor	2.8	7.3 a	6.3 ab	2.3 bc	5.8 a	7.5 a 6.2 ab 4.8 ab
PP-333	1.12	3.2 bc	4.5 b	2.0 bc	2.0 b	3.0 ce 2.7 cd 1.3 d
PP-333	2.2	2.7 bc	4.8 ab	2.0 bc	2.5 b	5.5 ad 3.8 ad 2.0 cd
Mefluidide + Chlorsulfuron	0.14 0.035	2.0 bc	5.2 ab	1.7 bc	2.8 b	5.2 ae 6.0 ab 1.0 d
Standard Error		0.9	0.6	0.7	0.8	1.1 0.8 0.8

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

improvements in quality on brome grass were recorded for the heavy rate of Mefluidide and Amido chlor and on tall fescue with EPTC, Amido chlor and the Mefluidide-Chlorsulfuron combination. EPTC and Amido chlor treatments each had a much better spectrum of species controlled. High and low rates of EPTC gave good quality improvements on timothy, fine fescue, perennial ryegrass, and tall fescue. The high EPTC treatment also scored well on redtop. The high rates of Amido chlor gave excellent quality response on brome grass and good control for redtop. Both Amido chlor application rates gave good to excellent quality response for fine fescue, perennial ryegrass and tall fescue.

Relative seedhead density ratings for 1983 are listed in Table 38. Both Mefluidide rates gave excellent seedhead density reductions on brome grass (although not statistically) and timothy, the high rate gave good inhibition for orchard grass. EPTC applied at both rates gave excellent seedhead density reductions for orchard grass, timothy, fine fescue, perennial ryegrass, and tall fescue while the high rate strongly inhibited redtop seedhead production. Both rates of Amido chlor provided excellent seedhead density reductions for brome grass (not statistically), fine fescue, perennial ryegrass, and tall fescue while orchard grass seedhead production was significantly reduced by the high rate only. The low rate of PP-333 gave good seedhead suppression only on tall fescue while the high rate of PP-333 produced good suppression of perennial ryegrass (not statistically) and tall fescue. The Mefluidide-Chlorsulfuron treatments exhibited good seedhead control for perennial ryegrass (not statistically) and tall fescue.

Table 39 reports average seedhead heights for six species. There are significant height reductions shown for some compounds on different

Table 38. DT4 PCR Compound-Species Interaction Studies-1983. Relative seedhead density. Visual estimates, 1 to 9 were 9 = greatest seedhead density. Liquid treatments applied 17 May and 18 May, 1983, dry applications made 20 May, 1983. Ratings taken on dates shown for 1983.

Treatment	Relative seedhead density							
	Bromegrass	Orchard- grass	Timothy	Fine fescue	Perennial ryegrass	Tall fescue	Redtop	
Chemical	Rate	13 June	7 July	13 June	20 July	13 July	20 July	
(kg/ha)								
Control	-	4.8 ad*	8.2 a*	7.5 a*	6.8 a*	6.5 ab*	7.5 a* 7.0 ab*	
Flurprimidol	1.12	4.7 ad	7.8 a	8.2 a	6.8 a	5.8 ac	3.7 bd 8.3 a	
Flurprimidol	2.2	5.2 ac	6.5 ab	6.2 ab	5.0 ab	7.8 a	3.3 bd 8.0 ab	
Mefluidide	0.28	1.7 d	6.0 ac	2.7 cd	6.5 a	6.2 ab	4.5 bc 6.3 ac	
Mefluidide	0.42	2.7 cd	3.3 bd	3.0 bd	4.7 ab	6.0 ac	5.2 ab 5.7 bc	
EPTC	5.6	5.3 ac	3.0 cd	2.3 cd	2.0 b	1.2 d	1.3 d 4.7 c	
EPTC	11.2	3.0 ad	2.0 d	1.3 d	1.8 b	1.0 d	1.5 cd 1.0 d	
Amidochlor	1.68	2.5 bd	6.2 ac	5.2 ac	2.3 b	1.8 cd	1.3 d 4.0 c	
Amidochlor	2.8	1.8 d	2.7 d	4.8 ac	2.2 b	1.3 d	1.7 cd 4.0 c	
PP-333	1.12	6.3 a	7.7 a	6.5 a	6.3 a	7.7 a	2.3 bd 8.0 ab	
PP-333	2.2	5.3 ac	6.0 ac	7.0 a	4.3 ab	3.0 bd	2.2 bd 8.3 a	
Mefluidide + Chlorsulfuron	0.14 0.035	6.2 ab	7.7 a	6.0 ab	3.8 ab	2.2 bd	1.5 cd 8.3 a	
Standard Error		1.0	1.0	1.0	1.0	1.3	0.9 0.7	

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 39. DT4 PGR Compound-Species Interaction Studies-1983. Average seedhead height. 6 subsamples per plot. Liquid treatments applied 17 May and 18 May, 1983, dry applications made 20 May, 1983. Ratings taken on dates shown in 1983.

Treatment	Chemical	Rate (kg/ha)	Seedhead height				
			Bromegrass	Timothy	Fine fescue	Perennial ryegrass	Redtop
			24 June (cm)	7 July (cm)	7 July (cm)	7 July (cm)	7 July (cm)
	Control	-	103.2 a*	99.4 a*	92.7 a*	56.1 a*	78.6 ac* 81.4 a*
	Flurprimidol	1.12	95.2 ab	100.4 a	84.4 ab	56.4 a	67.4 ab 85.4 ab
	Flurprimidol	2.2	76.1 bc	85.4 ab	68.6 bd	47.6 ad	56.8 bd 73.4 ad
	Mefluidide	0.28	78.7 ac	69.5 bc	86.4 ab	49.4 ac	73.5 ab 71.2 bc
	Mefluidide	0.42	48.0 d	69.5 bc	74.7 ac	50.3 ab	81.9 a 72.5 ac
	EPTC	5.6	91.4 ac	67.3 bc	38.8 e	30.3 de	38.7 df 70.9 be
	EPTC	11.2	81.6 ac	56.3 c	41.4 e	1.0 f	29.6 f 38.4 f
	Amidochlor	1.68	83.4 ac	86.6 ab	58.0 ce	31.7 ce	37.6 ef 58.5 de
	Amidochlor	2.8	83.2 ac	84.1 ab	47.8 de	17.2 ef	47.2 cf 58.3 e
	PP-333	1.12	71.6 bc	84.5 ab	85.2 ab	38.4 ad	60.7 bc 75.5 ac
	PP-333	2.2	68.7 cd	76.9 ac	55.8 ce	30.4 de	44.3 cf 68.1 ce
	Mefluidide	0.14	88.8 ac	72.7 bc	67.7 bd	32.2 be	48.9 ce 86.8 a
	+ Chlorsulfuron	0.035					
	Standard Error		7.6	7.9	6.9	5.6	5.6 4.5

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

species but there are few which would be considered practical. This is an important point for discussion. Examine the relative seedhead density score and average seedhead height value for redtop treated with the high rate of EPTC (Tables 38 and 39 respectively). The seedhead density on a relative rating scale is very low but the average seedhead height is almost 40 cm. This is a 50 percent height reduction compared to the control which is good, but in this case it is the seedhead density reduction which is the most important factor for the overall quality of the plots. Thus, it should be understood that if a few seedheads escape the PGR effects, the quality of control can still be superior if the quantity of seedheads produced is very low. In all the plots on utility turfs it was noted that at least a few seedheads were produced even with the most effective PGRs. Jagschitz et al. (43) reported studies where nearly all treatments had provided some amount of seedhead suppression but few had completely inhibited seedhead production.

Visual color quality was generally not dramatically affected by treatment. EPTC was the only compound which reduced color quality with any consistency (Table 40). EPTC at the high rate resulted in objectionable color losses for orchardgrass, timothy, perennial ryegrass, and tall fescue. The low rate of EPTC reduced the color ratings for orchardgrass. Amidochlor increased color ratings of perennial ryegrass at the low level only. The high rate of PP-333 produced color losses on bromegrass and tall fescue. Mefluidide-Chlorsulfuron treatments caused color losses for perennial ryegrass and improved color quality on tall fescue.

Discoloration (phytotoxic injury) ratings are reported in Table

Table 40. DT4 PCR Compound-Species Interaction Studies-1983. Visual color quality. Visual estimates, 1 to 9 where 1 = yellow and 9 = dark green. Liquid treatments applied 17 May and 18 May, 1983, dry applications made 20 May, 1983. Evaluated 7 July, 1983.

Treatment		Visual color quality					
Chemical	Rate (kg/ha)	Bromegrass		Orchard- grass		Timothy	
						Fine fescue	Perennial ryegrass
Control	-	7.2 a*	6.8 ab*	7.7 a*	7.5 ab*	7.2 bc*	7.0 ab*
Flurprimidol	1.12	7.2 a	6.3 ab	7.5 a	7.5 ab	7.2 bc	7.2 ab
Flurprimidol	2.2	7.2 a	6.5 ab	7.5 a	7.5 ab	7.3 ab	7.2 ab
Mefluidide	0.28	6.8 ac	6.8 ab	7.8 a	7.5 ab	7.2 bc	7.5 a
Mefluidide	0.42	6.8 ac	8.2 a	7.5 a	7.3 ab	7.5 ab	7.3 a
EPTC	5.6	7.0 ab	3.2 c	6.3 b	6.5 b	5.3 d	7.2 ab
EPTC	11.2	6.0 d	2.2 c	5.0 c	7.2 ab	4.5 e	6.5 b
Amidochlor	1.68	6.8 ac	6.7 ab	7.8 a	6.7 ab	7.5 ab	7.3 a
Amidochlor	2.8	6.3 bd	6.3 ab	8.0 a	7.0 ab	7.3 ab	7.3 a
PP-333	1.12	6.8 ac	6.0 b	7.7 a	7.7 a	6.2 cd	7.3 a
PP-333	2.2	6.2 cd	5.7 b	7.5 a	6.8 ab	4.8 e	7.3 a
Mefluidide + Chlorsulfuron	0.14 0.035	6.7 ac	7.3 ab	7.7 a	7.7 a	8.3 a	7.2 ab
Standard Error		0.2	0.6	0.2	0.2	0.3	0.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 41. DT4 PGR Compound-Species Interaction Studies-1983. Relative turf discoloration (phytotoxicity). Visual estimates, 1 to 9 where 1 = healthy turf and 9 = severe discoloration (low numbers are best). Liquid treatments applied 17 May and 18 May, 1983, dry applications made 20 May, 1983. Evaluations made 21 July, 1983.

Treatment		Turf discoloration - phytotoxicity			
Chemical	Rate (kg/ha)	Perennial			
		Orchardgrass	ryegrass	Tall fescue	Redtop
Control	-	4.8 bc*	2.3 ad*	2.0 c*	2.2 b*
Flurprimidol	1.12	5.2 ab	2.2 bd	2.2 c	1.0 b
Flurprimidol	2.2	5.8 ab	2.3 ad	1.7 c	1.0 b
Mefluidide	0.28	2.7 cd	1.5 cd	1.2 c	1.0 b
Mefluidide	0.42	2.3 d	2.3 ad	1.3 c	1.0 b
EPTC	5.6	5.5 ab	3.3 ac	5.8 b	2.0 b
EPTC	11.2	7.5 a	3.3 ac	7.8 a	5.0 a
Amidochlor	1.68	2.5 d	1.0 d	1.7 c	1.0 b
Amidochlor	2.8	2.3 d	1.8 bd	1.2 c	1.5 b
PP-333	1.12	6.3 ab	2.7 ad	5.7 b	1.0 b
PP-333	2.2	7.5 a	3.8 ab	7.7 a	1.0 b
Mefluidide + Chlorsulfuron	0.14 0.035	2.2 d	4.3 a	1.0 c	1.0 b
Standard Error		0.7	0.6	0.6	0.5

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

41. EPTC applications produced moderate discoloration of tall fescue from the light rate while the heavy rate severely injured orchardgrass and tall fescue and moderately injured redtop. PP-333 injured orchardgrass and tall fescue especially at the high rate.

Vegetative heights were recorded for 1983 only. This evaluation parameter was dropped because of the lodging found with most vegetative portions of these grass plants as discussed in section DT2. Table 42 shows average vegetative heights for six species. Statistically significant vegetative height reductions were found on several species and for several chemicals. The greatest percent height reduction for each grass was: perennial ryegrass (51%), redtop (45%), timothy (45%), Kentucky bluegrass (40%), orchardgrass (25%), and tall fescue (25%). However, these were not considered to be significant from a practical standpoint because seedhead height continued to be greater than the height of the vegetative portions of the turf sward.

1984 DT4 All Species

Table 43 gives the 1984 quality of control ratings for 3DT4 through 8DT4. Flurprimidol produced good overall control on tall fescue at both low and high rates but the response was not statistically different from the control. Good to excellent growth control was given by low and high rates of Mefluidide on orchardgrass, timothy, fine fescue, tall fescue, and redtop. Both rates of EPTC were scored good to very good for timothy, fine fescue, and redtop. Amidochlor provided good overall control of timothy at the high rate and perennial ryegrass at the low rate (although lacking statistical significance). Both high and low application rates of Amidochlor received good to very good quality

Table 42. DT4 PGR Compound-Species Interaction Study-1983. Vegetative height in cm. 6 subsamples per plot. Liquid treatments applied 17 May and 18 May, 1983, dry applications made 20 May, 1983. Measurements taken 24 June, 1983.

Treatment		Vegetative height					
Chemical	Rate	Kentucky bluegrass	Orchard-grass	Timothy	Perennial Ryegrass	Tall fescue	Redtop
	(kg/ha)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
Control	-	50.5 a*	27.8 a*	58.8 a*	24.0 a*	30.4 a*	41.3 a*
Flurprimidol	1.12	44.1 ab	23.9 ab	56.0 ab	21.4 ac	24.6 b	38.3 ab
Flurprimidol	2.2	39.4 be	24.3 ab	41.6 ac	20.7 ac	24.3 b	32.1 bc
Mefluidide	0.28	32.8 ce	25.3 ab	35.3 c	22.8 ab	30.8 a	32.7 ac
Mefluidide	0.42	32.3 de	27.7 a	48.4 ac	21.5 ac	30.5 a	28.1 cd
EPTC	5.6	41.7 bc	20.9 b	38.8 ac	13.2 bc	23.4 b	27.2 cd
EPTC	11.2	34.9 ce	20.8 b	32.4 c	13.4 bc	23.5 b	23.5 cd
Amidochlor	1.68	32.0 de	22.8 ab	45.8 ac	14.9 ac	22.6 b	23.5 cd
Amidochlor	2.8	30.7 e	24.3 ab	35.5 c	12.4 bc	23.0 b	22.4 d
PP-333	1.12	35.3 ce	26.9 ab	38.4 bc	15.5 ac	22.5 b	31.7 bd
PP-333	2.2	31.8 de	20.5 b	33.2 c	13.0 bc	22.6 b	28.5 cd
Mefluidide + Chlorsulfuron	0.14 0.035	40.4 bd	26.4 ab	38.2 bc	11.8 c	23.2 b	39.3 ab
Standard Error		2.7	1.9	6.1	3.1	1.5	2.8

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 43. DT4 PGR Compound-Species Interaction Studies-1984. Quality of control combining all factors. Visual estimates, 1 to 9 where 9 = ideal control. Liquid treatments applied 15 May, 1984, dry applications made 16 May, 1984. Evaluations made in 1984 on dates shown.

Treatment	Chemical	Rate (kg/ha)	Quality of control					
			Orchard- grass	Timothy	Fine fescue	Perennial ryegrass	Tall fescue	Redtop
			19 June	19 June	20 June	20 June	20 June	20 June
Control		-	4.2 c*	1.0 c*	3.8 f*	5.3 ab*	5.5 bc*	3.0 f*
Flurprimidol		1.12	5.3 bc	1.3 c	5.2 de	4.3 ac	6.7 ab	3.7 ef
Flurprimidol		2.2	5.0 bc	2.3 c	4.7 ef	5.8 ab	6.5 ab	4.7 de
Mefluidide		0.28	7.0 ab	6.8 a	7.3 a	5.2 ab	7.7 a	8.0 a
Mefluidide		0.42	6.8 ab	7.5 a	6.5 ac	4.7 ac	7.8 a	7.7 ab
EPTC		5.6	6.0 ac	7.7 a	6.0 bd	2.0 c	6.5 ab	6.2 bd
EPTC		11.2	5.3 bc	7.3 a	5.7 ce	2.2 c	5.7 bc	6.0 cd
Amidochlor		1.68	6.7 ab	2.0 c	7.0 ab	6.5 a	6.8 ab	6.7 ac
Amidochlor		2.8	7.5 a	6.3 ab	7.0 ab	3.5 bc	6.8 ab	6.3 bd
PP-333		1.12	5.3 bc	2.0 c	5.2 de	4.3 ac	5.8 bc	3.7 ef
PP-333		2.2	5.5 ac	4.5 b	4.7 ef	5.7 ab	7.0 ab	4.8 de
Mefluidide + Chlorsulfuron		0.14 0.035	5.8 ac	6.0 ab	6.7 ac	2.0 c	4.3 c	3.8 ef
Standard Error			0.6	0.6	0.3	0.8	0.5	0.5

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

ratings on orchardgrass, fine fescue, tall fescue (not statistical), and redtop. PP-333 gave good control with the heavy application on tall fescue. The Mefluidide-Chlorsulfuron treatments gave good overall quality of control on timothy and fine fescue.

Vegetative density ratings are found in Table 44. Flurprimidol gave variable responses on several grasses. Mefluidide at the high rate resulted in moderate vegetative density reduction on fine fescue and perennial ryegrass, and slight responses on other grasses. High and low rates of EPTC gave statistically significant density reductions on all grasses. Vegetative density reductions for high and low rates of EPTC ranged from slight for timothy and redtop, to severe for perennial ryegrass. Perennial ryegrass, fine fescue, tall fescue, and redtop plots showed slight to major vegetative density reductions from Amidochlor applications. PP-333 resulted in some reduction in density on fine fescue, perennial ryegrass, and tall fescue. The Mefluidide-Chlorsulfuron treatments caused small reductions in density on timothy, fine fescue, and redtop; significant density reductions of tall fescue; and severe density reduction on perennial ryegrass plots.

Relative seedhead density ratings can be found in Table 45. In general, excellent results were found for this parameter. Many compounds dramatically reduced seedhead density and some gave nearly complete inhibition of seedhead production depending on the individual grass species. Flurprimidol gave good seedhead suppression for the high rate on fine fescue and very good reductions for perennial ryegrass and tall fescue at both rates. Mefluidide and EPTC treatments at both rates gave very good to excellent seedhead density reductions for all species tested. All grasses except timothy showed very good reductions of

Table 44. DT4 PCR Compound-Species Interaction Studies-1984. Vegetative density. Visual estimates, 1 to 9 where 9 = greatest vegetative density. Liquid treatments applied 15 May, 1984, dry applications made 16 May, 1984. Evaluations made in 1984 on the dates shown.

Treatment	Chemical	Rate (kg/ha)	Vegetative density					
			Orchard- grass 19 June	Timothy 19 June	Fine fescue 20 June	Perennial ryegrass 20 June	Tall fescue 20 June	Redtop 20 June
Control		-	7.5 ab*	9.0 a*	8.2 a*	6.7 a*	8.8 a*	8.0 a*
Flurprimidol		1.12	8.0 a	8.8 a	6.5 bd	4.5 ac	7.7 bc	8.3 ac
Flurprimidol		2.2	8.2 a	8.5 ab	7.3 ab	5.7 ab	7.5 bd	7.7 bd
Mefluidide		0.28	7.2 ab	7.2 bd	7.0 ac	5.8 ab	7.0 bd	7.5 bd
Mefluidide		0.42	5.7 c	6.7 d	5.2 dg	4.0 bd	6.7 cd	7.3 ce
EPTC		5.6	4.2 d	7.2 bd	3.7 g	2.0 d	5.7 ef	6.3 ef
EPTC		11.2	4.2 d	7.0 cd	4.2 fg	1.8 d	5.3 f	6.0 f
Amidochlor		1.68	7.8 a	8.7 a	5.8 ce	5.5 ab	6.8 cd	7.0 df
Amidochlor		2.8	8.3 a	8.2 ac	5.0 ef	3.0 cd	6.5 de	6.3 ef
PP-333		1.12	7.7 a	8.8 a	6.8 bc	3.8 bd	8.0 ab	8.5 ab
PP-333		2.2	7.8 a	8.8 a	6.8 bc	5.7 ab	7.5 bd	8.0 ad
Mefluidide + Chlorsulfuron 0.035		0.14	6.3 ac	7.2 bd	6.0 be	1.7 d	3.8 g	7.8 bd
Standard Error			0.4	0.4	0.4	0.7	0.3	0.3

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 45. DT4 PGR Compound-Species Interaction Studies-1984. Relative seedhead density. Visual estimates, 1 to 9 where 9 = greatest seedhead density. Liquid treatments applied 15 May, 1984, dry applications made 16 May, 1984. Evaluated 1 Aug, 1984.

Treatment		Relative seedhead density					
Chemical	Rate (kg/ha)	Orchard- grass	Timothy	Fine fescue	Perennial ryegrass	Tall fescue	Redtop
Control	-	5.2 a*	9.0 a*	6.3 a*	6.8 ab*	4.0 a*	8.7 a*
Flurprimidol	1.12	6.7 a	8.2 ab	5.5 ab	4.2 cd	2.0 bc	6.8 a
Flurprimidol	2.2	6.3 a	7.0 bc	3.7 b	4.8 bc	2.2 bc	7.7 a
Mefluidide	0.28	1.3 b	1.2 e	1.0 c	2.3 de	1.0 c	1.8 b
Mefluidide	0.42	1.5 b	1.2 e	1.0 c	1.5 e	1.0 c	1.7 b
EPTC	5.6	1.0 b	2.0 e	1.0 c	1.2 e	1.0 c	1.0 b
EPTC	11.2	1.2 b	1.7 e	1.0 c	1.2 e	1.0 c	1.0 b
Amidochlor	1.68	1.7 b	8.2 ab	1.2 c	1.7 e	1.0 c	2.2 b
Amidochlor	2.8	1.7 b	5.7 c	1.0 c	1.3 e	1.0 c	2.0 b
PP-333	1.12	6.8 a	7.2 bc	4.5 ab	4.5 cd	2.8 ab	7.3 a
PP-333	2.2	5.2 a	7.3 bc	6.2 a	7.5 a	2.8 ab	8.8 a
Mefluidide + Chlorsulfuron	0.14 0.035	2.5 b	3.7 d	1.3 c	1.0 e	1.0 c	7.2 a
Standard Error		0.6	0.4	0.6	0.7	0.4	0.8

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

seedhead density when treated with low or high rates of Amidochlor. Mefluidide-Chlorsulfuron treatments results in good to excellent seedhead density reduction for all species except redtop. Although there were other significant responses they were not different enough from the control plots to be considered advantageous for practical applications.

Average seedhead heights for species are presented in Table 46. As described in the discussion of the 1983 DT4 studies, actual seedhead height reductions may not correspond closely to relative seedhead density reductions shown in Table 45 and discussed previously. Many PGR treatments reduced seedhead height by more than 50 percent. Some compounds inhibited seedhead production all together those plots received a rating of 1.0. For an example compare the seedhead density ratings and seedhead height for redtop treated with the high rate of Mefluidide (Tables 45 and 46 respectively). These two ratings seem contradictory but in fact this is not an unusual response. Nearly always a few seedheads are produced no matter how ideally the PGR seems to work. Again, the point to note is that if a few seedheads are produced and grow tall, the quality of overall control for a utility turf may still be considered superior as long as the quantity of seedheads produced is low.

Turf discoloration (phytotoxicity) ratings are shown in Table 47. Flurprimidol had little to no effect on any grass. Mefluidide at low rates produced slight to moderate injury of redtop, tall fescue, fine fescue, timothy and orchardgrass while injury was moderately severe on perennial ryegrass. The high rate of Mefluidide produced turf injury which varied from slight on tall fescue and redtop, to moderate on fine

Table 46. DT4 PCR Compound-Species Interaction Studies-1984. Average seedhead height. 6 subsamples taken per plot. Liquid treatments applied 15 May, 1984, dry applications made 16 May, 1984. Evaluations made in 1984 on the dates shown.

Treatment	Chemical	Rate (kg/ha)	Seedhead height					
			Orchard- grass	Timothy	Fine fescue	Perennial ryegrass	Tall fescue	Redtop
			30 July (cm)	30 July (cm)	30 July (cm)	1 August (cm)	30 July (cm)	30 July (cm)
	Control	-	67.3 a*	91.8 a*	59.2 a*	36.0 a*	54.9 a*	66.9 a*
	Flurprimidol	1.12	59.9 ab	81.9 ab	47.5 ab	33.4 ab	37.7 b	62.3 ac
	Flurprimidol	2.2	56.2 ab	72.4 ab	43.5 ab	31.7 ab	36.2 b	64.1 ab
	Mefluidide	0.28	34.8 de	44.5 d	32.0 bd	27.8 ab	14.4 c	52.8 ad
	Mefluidide	0.42	20.8 ef	40.5 d	13.9 de	29.8 ab	1.0 c**	50.9 bd
	EPTC	5.6	18.6 f	45.6 d	1.0 e	11.1 c	1.0 c	14.9 e
	EPTC	11.2	19.6 f	31.7 d	1.0 e	10.5 c	1.0 c	1.0 f
	Amidochlor	1.68	35.6 de	78.2 ab	31.6 bd	32.4 ab	1.0 c	48.3 cd
	Amidochlor	2.8	27.0 ef	71.0 b	20.4 cd	9.5 c	1.0 c	47.3 d
	PP-333	1.12	46.0 bc	73.2 ab	46.7 ab	34.3 ab	42.1 ab	60.4 ad
	PP-333	2.2	50.3 bc	67.4 bc	42.3 ab	33.5 ab	35.0 b	60.3 ad
	Mefluidide + Chlorsulfuron 0.035	0.14	37.3 ce	50.2 cd	34.5 bc	18.3 bc	1.0 c	59.3 ad
	Standard Error		4.4	6.1	6.1	4.8	4.5	4.4

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

** Where less than six seedheads were located the average height was calculated from those available, if less than three seedheads were found on a given plot the average was reported as 1.0.

Table 47. DT4 PGR Compound-Species Interaction Studies-1984. Relative turf discoloration (phytotoxicity). Visual estimates, 1 to 9 where 1 = severe injury and 9 = healthy turf. Liquid treatments applied 15 May, 1984, dry applications made 16 May, 1984. Evaluations made in 1984 on the dates shown.

Treatment	Turf discoloration-phytotoxicity									
	Species and date of evaluation									
	Orchardgrass		Timothy		Fine fescue		Perennial ryegrass		Tall fescue	
Chemical	Rate	19 June	19 June	19 June	20 June	20 June	20 June	20 June	20 June	20 June
	(kg/ha)									
Control	-	7.5 a*	9.0 a*	8.8 a*	7.3 a*	8.8 a*	9.0 a*	8.8 a*	9.0 a*	8.8 a*
Flurprimidol	1.12	8.0 a	8.8 a	8.0 a	5.0 ad	7.7 ac	8.3 ab	7.7 ac	8.3 ab	8.3 ab
Flurprimidol	2.2	8.0 a	6.8 ad	8.2 a	5.2 ad	7.5 ad	8.0 ab	7.5 ad	8.0 ab	8.0 ab
Mefluidide	0.28	5.7 b	5.8 cd	7.5 a	4.8 ad	6.7 cf	7.0 cd	6.7 cf	7.0 cd	7.0 cd
Mefluidide	0.42	3.8 cd	4.7 d	5.5 c	4.0 be	6.5 cf	6.8 cd	6.5 cf	6.8 cd	6.8 cd
EPTC	5.6	3.0 d	5.5 cd	3.7 de	1.7 e	5.5 f	5.7 e	5.5 f	5.7 e	5.7 e
EPTC	11.2	2.5 d	5.5 cd	3.3 de	2.7 de	5.5 f	5.5 e	5.5 f	5.5 e	5.5 e
Amidochlor	1.68	7.5 a	8.7 a	7.2 ab	6.5 ab	6.3 df	6.8 cd	6.3 df	6.8 cd	6.8 cd
Amidochlor	2.8	5.3 bc	7.5 ac	5.2 cd	3.2 ce	6.0 ef	6.0 de	6.0 ef	6.0 de	6.0 de
PP-333	1.12	7.8 a	9.0 a	8.0 a	4.5 ae	8.2 ab	8.7 ab	8.2 ab	8.7 ab	8.7 ab
PP-333	2.2	7.8 a	8.5 ab	7.8 a	6.2 ac	7.3 be	8.2 ab	7.3 be	8.2 ab	8.2 ab
Mefluidide	0.14	4.7 bc	6.3 bd	5.7 bc	2.7 de	2.3 g	7.8 bc	2.3 g	7.8 bc	7.8 bc
+ Chlorsulfuron	0.035									
Standard Error		0.5	0.7	0.5	0.9	0.4	0.3	0.4	0.3	0.3

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

fescue and to moderately severe on orchardgrass, timothy and perennial ryegrass. EPTC produced significant injury at both rates for all grasses tested particularly on orchardgrass, fine fescue and perennial ryegrass. The high rate of Amidochlor produced slight discoloration or injury on orchardgrass and fine fescue plots and significantly adverse effects were recorded for the perennial ryegrass. The Mefluidide-Chlorsulfuron treatments adversely affected four of the six species tested. All other unmentioned compounds and rates applied to each species block did not produce negative effects of sufficient magnitude to be considered objectionable.

Mowing Energy Study DT5

The primary goal of this investigation was to determine whether or not the use of PGRs would result in energy savings when or if mechanical mowing became necessary. It was assumed that by reducing the bulk of vegetative growth and by the inhibition of seedhead production, mowing energy consumption would logically be reduced. Shearing and Batch (61) stated that the size, weight and energy requirements of the mowing machine needed will be determined by the bulk of grass to be mowed. In addition to the physical measurement of mowing energy requirements, several evaluation parameters similar to those used to judge the other studies were recorded. The plot area as a whole was not particularly well suited to intensive investigative work because of limited turf quality.

1983 1DT5

Quality of control ratings were taken on two dates for 1983 and are presented in Table 48. The inconsistency of the plots contributed to the variable responses found for this evaluation parameter. EPTC treated plots at low and high rates were scored the lowest on both evaluation dates and were considered objectionable due to excess discoloration and thinning. Both rates of the Mefluidide-Chlorsulfuron combination received moderate quality of control scores on the first rating date and improved by the second rating. Mefluidide at both rates was also given good marks for the second evaluation date, 8 July, 1983. Variability of the results for all other compound applications corresponded to the lack of statistical significance found for the remainder of results recorded for this evaluation parameter. Both EPTC treatments caused severe vegetative density reductions for 1983 (Table 49), while all other compounds did not affect density ratings. All treatments but Amidochlor reduced the turf color quality when evaluated 7 June, 1983 (Table 50).

Relative seedhead density was reduced by nearly all treatments. Only the low rate of Amidochlor did not inhibit seedhead production (Table 51). Most compounds provided seedhead suppression which would be considered good to excellent. Average vegetative heights (Table 52) were reduced by Mefluidide, EPTC, Mefluidide-Chlorsulfuron combinations and Amidochlor at the higher rate. Reductions ranged from seven to 43 percent. Relative vegetative growth was a visual evaluation of vegetative growth/density similar to but not the same as average vegetative height. Table 53 gives the values for this parameter evaluated 7 June, 1983. The results were much the same as those

Table 48. 1DT5 and 2DT5 Mowing Energy Study-1983 and 1984. Quality of control combining all factors. Visual estimates, 1 to 9 where 9 = ideal control. Plots treated 11 May, 1983 and 14 May, 1984. Evaluations made in 1983 and 1984 on the dates shown.

Treatment		Quality of control			
Chemical	Rate (kg/ha)	1983		1984	
		17 June	8 July	22 June	2 Aug
Control	-	4.4 a*	3.0 bc*	4.4 b*	2.1 b*
Mefluidide	0.14	3.5 ab	5.9 a	5.4 ab	5.3 ab
Mefluidide	0.28	2.4 b	5.6 ab	4.8 ab	4.8 ab
EPTC	5.6	2.1 b	3.0 bc	4.0 b	3.4 ab
EPTC	11.2	2.1 b	2.3 c	4.8 ab	3.9 ab
Amidochlor	1.12	4.1 ab	3.0 bc	4.0 b	2.0 b
Amidochlor	2.2	5.4 a	4.6 ac	4.9 ab	4.0 ab
Mefluidide	0.07	4.8 a	5.6 ab	6.9 a	6.8 a
+ Chlorsulfuron	0.035				
Mefluidide	0.14	3.6 ab	6.9 a	6.0 ab	6.3 a
+ Chlorsulfuron	0.035				
Standard Error		0.6	0.8	0.7	1.1

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 49. 1DT5 and 2DT5 Mowing Energy Study—1983 and 1984. Vegetative density all species combined. Visual estimates, 1 to 9 where 9 = greatest vegetative density. Plots treated 11 May, 1983 and 14 May, 1984. Evaluations made for 1983 and 1984 on the dates shown.

Treatment		Vegetative density		
Chemical	Rate (kg/ha)	1983	1984	
		8 July	22 June	2 Aug
Control	—	7.4 a*	6.5 a*	6.1 ab*
Mefluidide	0.14	6.5 a	4.3 cd	4.5 ac
Mefluidide	0.28	5.8 a	4.5 bd	4.3 bc
EPTC	5.6	3.6 b	3.9 cd	3.5 c
EPTC	11.2	2.1 b	2.9 d	3.1 c
Amidochlor	1.12	7.1 a	7.0 a	6.1 ab
Amidochlor	2.2	6.9 a	5.5 ac	5.6 ab
Mefluidide	0.07	6.8 a	6.0 ab	6.5 a
+ Chlorsulfuron	0.035			
Mefluidide	0.14	7.5 a	6.4 a	6.5 a
+ Chlorsulfuron	0.035			
Standard Error		0.5	0.5	0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 50. IDT5 Mowing Energy Study-1983. Visual color quality, 1 to 9 where 1 = yellow and 9 = dark green. Plots treated 11 May, 1983. Evaluated 7 June, 1983.

<u>Treatment</u>		
<u>Chemical</u>	<u>Rate</u>	<u>Color quality</u>
	(kg/ha)	
Control	-	6.9 a*
Mefluidide	0.14	2.5 b
Mefluidide	0.28	2.3 b
EPTC	5.6	2.4 b
EPTC	11.2	2.4 b
Amidochlor	1.12	6.4 a
Amidochlor	2.2	5.8 a
Mefluidide	0.07	3.8 b
+ Chlorsulfuron	0.035	
Mefluidide	0.14	2.9 b
+ Chlorsulfuron	0.035	
Standard Error		0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 51. 1DT5 and 2DT5 Mowing Energy Study-1983 and 1984.
 Relative seedhead density all species combined. Visual
 estimates, 1 to 9 where 9 = greatest seedhead density.
 Plots treated 11 May, 1983 and 14 May, 1984.

<u>Treatment</u>		<u>Relative seedhead density</u>	
		<u>1983</u>	<u>1984</u>
<u>Chemical</u>	<u>Rate</u>	<u>8 July</u>	<u>2 Aug</u>
	(kg/ha)		
Control	-	7.8 a*	7.4 a*
Mefluidide	0.14	3.0 c	1.6 c
Mefluidide	0.28	1.9 c	1.3 c
EPTC	5.6	2.0 cd	2.6 bc
EPTC	11.2	1.0 d	1.8 c
Amidochlor	1.12	7.9 a	7.5 a
Amidochlor	2.2	5.0 b	5.0 ab
Mefluidide	0.07	3.5 bc	2.8 bc
+ Chlorsulfuron	0.035		
Mefluidide	0.14	2.1 cd	3.1 bc
+ Chlorsulfuron	0.035		
Standard Error		0.6	0.9

* Means within columns with like letters do not differ
 significantly according to Duncan's Multiple Range Test (5%).

Table 52. 1DT5 Mowing Energy Study-1983. Vegetative height in cm
6 subsamples per plot. Plots treated 11 May, 1983.
Evaluated 17 June, 1983.

Treatment Chemical	Rate	Vegetative height
	(kg/ha)	(cm)
Control	-	13.3 a*
Mefluidide	0.14	8.1 d
Mefluidide	0.28	7.9 d
EPTC	5.6	7.7 d
EPTC	11.2	7.6 d
Amidochlor	1.12	12.4 ab
Amidochlor	2.2	10.7 bc
Mefluidide	0.07	9.7 cd
+ Chlorsulfuron	0.035	
Mefluidide	0.14	8.9 cd
+ Chlorsulfuron	0.035	
Standard Error		0.7

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 53. IDT5 Mowing Energy Study-1983. Relative vegetative growth (height) and density combined. Visual estimates, 1 to 9 where 9 = greatest vegetative growth/density. Plots treated 11 May, 1983. Evaluated 7 June, 1983.

Treatment		Relative vegetative growth
Chemical	Rate (kg/ha)	
Control	-	7.5 a*
Mefluidide	0.14	3.4 c
Mefluidide	0.28	2.3 c
EPTC	5.6	2.3 c
EPTC	11.2	2.4 c
Amidochlor	1.12	6.8 ab
Amidochlor	2.2	5.8 b
Mefluidide	0.07	3.4 c
+ Chlorsulfuron	0.035	
Mefluidide	0.14	2.8 c
+ Chlorsulfuron	0.035	
Standard Error		0.5

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

described for the average vegetative height reported in Table 52 and discussed previously.

Energy consumption was measured by recording the watts of electrical energy used to mow like-sized plot areas. Energy consumption was reduced statistically by both rates of Mefluidide, EPTC and the Mefluidide-Chlorsulfuron combination (Table 54). It is questionable whether the magnitude of the reduction is sufficient to give mowing energy reductions great enough to result in economic benefit. Weed population index ratings were made 8 July, 1983, nearly eight weeks after treatment (Table 55). Only the two Mefluidide-Chlorsulfuron treatments were found to reduce weed populations. Several authors have noted weed encroachment as a common problem in PGR treated turfs (22,26,64,65,83). Tank-mixing broad spectrum broadleaf herbicides with PGRs was recommended to counteract weed infestation.

1984 2DT5

Quality of control ratings were improved only for the Mefluidide-Chlorsulfuron treatments (Table 48). Responses from all other compounds were not sufficiently different from the control. The appearance of several plots would be considered objectionable. For example, EPTC treatments caused severe turf thinning when evaluated at five and ten weeks after treatment (Table 49). Literature sources report wide variation in the severity of discoloration and in most cases, severe long lasting was more the exception than the rule (12,13,25,59,69,70,72,84). Mefluidide and Amidochlor treatments and Mefluidide-Chlorsulfuron combinations moderately reduced or did not affect turf density respectively. Relative seedhead density (Table 51)

Table 54. 1DT5 and 2DT5 Mowing Energy Study-1983 and 1984.
 Energy consumption as Watts used to mow like plot
 areas, 2 passes accumulated. Plots treated 11 May, 1983
 and 14 May, 1984. Evaluations made in 1983 and 1984
 on the dates shown.

Treatment		Watts used	
Chemical	Rate (kg/ha)	8 July 83	2 Aug 84
Control	-	758 a*	637 ac*
Mefluidide	0.14	725 bc	633 ac
Mefluidide	0.28	710 c	622 bc
EPTC	5.6	713 c	630 ac
EPTC	11.2	700 c	617 c
Amidochlor	1.12	766 a	645 ab
Amidochlor	2.2	750 ab	633 ac
Mefluidide	0.07	722 bc	647 a
+ Chlorsulfuron	0.035		
Mefluidide	0.14	714 c	639 ac
+ Chlorsulfuron	0.035		
Standard Error		9.0	7.0

* Means within columns with like letters do not differ
 significantly according to Duncan's Multiple Range Test (5%).

Table 55. 1DT5 and 2DT5 Mowing Energy Study-1983 and 1984. Weed population index. Visual estimates, 1 to 9 where 9 = greatest weed population. Plots treated 11 May, 1983 and 14 May, 1984. Evaluation made in 1983 and 1984 on the dates shown.

Treatment		Weed population index	
Chemical	Rate (kg/ha)	8 July 83	2 Aug 84
Control	-	4.8 ab*	2.5 ab*
Mefluidide	0.14	5.3 ab	2.8 a
Mefluidide	0.28	4.9 ab	2.1 ab
EPTC	5.6	5.9 ab	3.3 a
EPTC	11.2	6.4 a	3.3 a
MON-4612	1.12	3.8 b	2.6 ab
MON-4612	2.2	4.9 ab	1.8 ab
Mefluidide	0.07	1.3 c	1.3 b
+ Chlorsulfuron	0.035		
Mefluidide	0.14	1.5 c	1.4 b
+ Chlorsulfuron	0.035		
Standard Error		0.7	0.5

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

was very substantially reduced by all treatments except Amidochlor. Mefluidide was most effective followed by EPTC and the Mefluidide-Chlorsulfuron combinations. No statistical differences were found for mowing energy requirements for this study in 1984 (Table 54).

Weed populations (Table 55) were low on all plots so no significant responses were noted although the plots treated with the Mefluidide-Chlorsulfuron combinations had the fewest weeds. The entire area received two broadleaf herbicide treatments in 1984 since weed infestation makes evaluation of grass responses very difficult.

PGR Compound, Rate and Mixture Study DT6

Several PGR compounds and selected PGR-herbicide combinations were applied to determine their efficacy on a stand of highway grasses. The manufacturers recommended rates were used as heavy rates while light rates were one half of those rates. Kentucky bluegrass and quackgrass were the primary grass species on this site. Lesser amounts of fine fescue, orchardgrass and redtop were also present. Appendix Table 67 shows the dates of rainfall after treatments. In 1983 0.2 cm fell five days after treatments and 1.9 cm was reported ten days after the 9 May treatment date. The 1984 applications were made 5 May and followed by 0.17 cm of rain 6 May and 1.1 cm 7 May. The elapsed time from the time of application to the first significant rainfall is very important with respect to the efficacy of any particular PGR compound. Logically it follows that the activity of foliarly absorbed PGRs would be enhanced by a longer period of leaf contact before a rainfall. Conversely, it seems likely that crown and/or root absorbed PGRs benefit from normal rainfall during or soon after treatment. The grass plant should be actively

growing at the time of application regardless of the uptake characteristics of the PGR to be used.

1983 1DT6

Quality of control ratings were taken at approximately five and ten weeks after treatment. The combinations of Mefluidide and Amidochlor with Chlorsulfuron and Amidochlor alone were given the highest scores on 14 June (Table 56). Despite this, the quality ratings of all plots were not sufficient to be considered satisfactory. By the 19 July evaluation date both rates of Mefluidide and both Mefluidide-Chlorsulfuron combinations were scored the highest and were considered acceptable for a utility turf area. The quality of all other plots was generally greater than that of the control but the magnitude of the improvements were not dramatic enough to suggest practical significance. Vegetative density was not measurably affected by any treatment or compound in 1983 (Table 57).

Excellent relative seedhead density ratings were found on both evaluation dates for each application rate of Mefluidide, EPTC and Mefluidide-Chlorsulfuron combination (Table 58). These treatments had almost completely inhibited seedhead production (a value of 1.0 indicates complete seedhead inhibition). Amidochlor and Amidochlor-Chlorsulfuron treatments did provide seedhead inhibition at an intermediate level. Flurprimidol and PP-333 were ineffective seedhead inhibitors in this study.

Kentucky bluegrass and quackgrass seedheads were almost completely inhibited by Mefluidide and Mefluidide-Chlorsulfuron treatments (Table 59 and 60). EPTC produced similar reductions on Kentucky bluegrass

Table 56. 1DT6 and 2DT6 PGR Compound, Rate and Mixture Study-1983 and 1984. Quality of control combining all factors. Visual estimates, 1 to 9 where 9 = ideal control. Plots treated 6 May, 1983 and 5 May, 1984. Evaluations made in 1983 and 1984 on the dates shown.

Treatment		Quality of control				
Chemical	Rate (kg/ha)	1983		1984		
		14 June	19 July	30 May	25 June	25 July
Control	-	3.0 ef*	2.3 e*	3.4 ef*	3.0 c*	1.1 e*
Flurprimidol	1.12	3.1 df	2.9 de	3.6 df	3.5 c	1.1 e
Flurprimidol	2.2	3.5 cf	2.4 e	3.5 df	3.6 bc	1.4 e
Mefluidide	0.28	3.0 ef	5.8 ab	7.1 ab	6.5 a	8.6 a
Mefluidide	0.42	2.5 f	5.8 ab	7.9 a	6.4 a	8.9 a
EPTC	5.6	3.6 be	3.6 ce	4.5 ce	3.1 c	2.3 ce
EPTC	11.2	3.3 df	4.0 cd	4.3 cf	3.0 c	1.4 e
Amidochlor	1.12	4.4 ac	4.1 cd	4.4 ce	4.0 bc	2.8 ce
Amidochlor	2.2	4.6 ab	5.6 b	5.1 c	4.0 bc	5.3 b
PP-333	1.12	4.0 ae	3.6 ce	3.0 f	4.1 bc	1.6 e
PP-333	2.2	3.6 be	3.9 cd	3.0 f	3.1 c	1.4 e
Mefluidide + Chlorsulfuron	0.07 0.035	4.8 a	6.6 a	6.5 b	4.1 bc	3.4 cd
Mefluidide +Chlorsulfuron	0.14 0.035	3.3 df	7.0 a	7.3 ab	4.9 b	6.4 b
Amidochlor + Chlorsulfuron	0.84 0.035	4.1 ad	4.3 c	5.1 c	3.6 bc	1.8 de
Amidochlor + Chlorsulfuron	1.68 0.035	4.5 ac	5.5 b	4.8 cd	3.9 bc	3.5 c
Standard Error		0.3	0.4	0.4	0.4	0.5

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 57. 1DT6 and 2DT6 PGR Compound, Rate and Mixture Study-1983 and 1984. Vegetative density all species combined. Visual estimates, 1 to 9 where 9 = greatest vegetative density. Plots treated 6 May, 1983 and 5 May, 1984. Evaluations made in 1983 and 1984 on the dates shown.

Treatment		Vegetative density		
Chemical	Rate (kg/ha)	1983	1984	
		19 July	30 May	25 June
Control	-	5.5 ab*	7.4 a*	7.5 a*
Flurprimidol	1.12	5.8 a	7.3 a	6.6 ac
Flurprimidol	2.2	5.6 ab	7.5 a	6.4 ac
Mefluidide	0.28	5.0 b	5.1 e	5.5 ad
Mefluidide	0.42	5.3 ab	4.9 e	4.3 d
EPTC	5.6	5.1 ab	6.8 ab	5.0 bd
EPTC	11.2	4.9 b	7.3 a	5.0 cd
Amidochlor	1.12	5.4 ab	6.9 ab	5.3 bd
Amidochlor	2.2	5.4 ab	6.6 b	5.6 ad
PP-333	1.12	5.4 ab	7.5 a	6.5 ac
PP-333	2.2	5.4 ab	7.5 a	6.3 ad
Mefluidide	0.07	5.8 a	5.9 cd	5.8 ad
+ Chlorsulfuron	0.035			
Mefluidide	0.14	5.8 a	5.5 de	6.8 ac
+ Chlorsulfuron	0.035			
Amidochlor	0.84	5.8 a	7.1 ab	7.1 ab
+ Chlorsulfuron	0.035			
Amidochlor	1.68	5.6 ab	6.5 bc	6.4 ac
+ Chlorsulfuron	0.035			
Standard Error		0.2	0.2	0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 58. DT6 PGR Compound, Rate and Mixture Study-1983 and 1984. Relative seedhead density all species combined. Visual estimates, 1 to 9 where 9 = greatest seedhead density. Plots treated 6 May, 1983 and 5 May, 1984. Evaluation made in 1983 and 1984 on the dates shown.

Treatment		Relative seedhead density		
Chemical	Rate (kg/ha)	1983		1984
		14 June	19 July	25 July
Control	-	7.1 a*	7.1 a*	8.6 a*
Flurprimidol	1.12	5.8 ab	6.6 a	8.8 a
Flurprimidol	2.2	6.4 a	7.0 a	8.0 ab
Mefluidide	0.28	1.0 f	1.1 e	1.5 e
Mefluidide	0.42	1.0 f	1.1 e	1.0 e
EPTC	5.6	1.4 ef	2.4 e	7.6 ab
EPTC	11.2	1.1 f	1.9 e	8.5 a
Amidochlor	1.12	4.3 bc	5.3 bc	6.8 ac
Amidochlor	2.2	2.6 df	4.8 cd	5.3 cd
PP-333	1.12	5.6 ab	6.6 a	8.6 a
PP-333	2.2	5.5 ab	6.4 ab	8.4 a
Mefluidide	0.07	2.1 df	1.9 e	6.4 bc
+ Chlorsulfuron	0.035			
Mefluidide	0.14	1.4 ef	1.5 e	3.9 d
+ Tlear	0.035			
Amidochlor	0.84	3.5 cd	4.9 cd	7.0 ab
+ Chlorsulfuron	0.035			
Amidochlor	1.68	2.8 ce	3.9 d	6.3 bc
+ Chlorsulfuron	0.035			
Standard Error		0.5	0.4	0.6

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 59. 1DT6 and 2DT6 PGR Compound, Rate and Mixture Study-1983 and 1984. Kentucky bluegrass seedhead heights in cm. 8 subsamples per plot. Plots treated 6 May, 1983 and 5 May, 1984. Evaluations made in 1983 and 1984 on the dates shown.

Treatment		Seedhead heights	
Chemical	Rate (kg/ha)	1983	1984
		20 July (cm)	25 July (cm)
Control	-	47.8 a*	44.4 a*
Flurprimidol	1.12	38.3 b	37.2 ab
Flurprimidol	2.2	35.5 bc	30.5 bd
Mefluidide	0.28	1.0 g**	6.5 gh
Mefluidide	0.42	1.0 g	1.0 h
EPTC	5.6	1.0 g	11.7 fg
EPTC	11.2	1.0 g	10.0 fg
Amidochlor	1.12	29.4 df	24.0 de
Amidochlor	2.2	25.2 f	17.9 ef
PP-333	1.12	34.5 bc	32.6 bd
PP-333	2.2	31.8 cd	28.6 bd
Mefluidide	0.07	1.0 g	36.2 ab
+ Chlorsulfuron	0.035		
Mefluidide	0.14	1.0 g	32.3 bd
+ Chlorsulfuron	0.035		
Amidochlor	0.84	29.8 de	31.6 bd
+ Chlorsulfuron	0.035		
Amidochlor	1.68	26.4 ef	27.7 cd
+ Chlorsulfuron	0.035		
Standard Error		1.4	2.8

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

** Where less than eight seedheads were located the average was calculated from those available, if less than four seedheads were found on a given plot the average was reported as 1.0.

Table 60. 1DT6 and 2DT6 PGR Compound, Rate and Mixture Study-1983 and 1984. Quackgrass seedhead heights in cm. 8 subsamples per plot. Plots treated 6 May, 1983 and 5 May, 1984. Evaluations made in 1983 and 1984 on the dates shown.

Treatment		Seedhead heights	
Chemical	Rate	1983 20 July	1984 25 July
	(kg/ha)		
Control	-	54.1 ab*	47.6 bd*
Flurprimidol	1.12	57.8 a	54.6 a
Flurprimidol	2.2	57.1 a	47.8 bd
Mefluidide	0.28	1.0 c	1.0 e
Mefluidide	0.42	1.0 c	1.0 e
EPTC	5.6	55.9 ab	49.2 b
EPTC	11.2	54.6 ab	46.3 bd
Amidochlor	1.12	51.9 ab	45.1 bd
Amidochlor	2.2	38.2 b	47.4 bd
PP-333	1.12	56.0 ab	48.8 b
PP-333	2.2	52.1 ab	46.5 bd
Mefluidide	0.07	1.0 c	42.8 cd
+ Chlorsulfuron	0.035		
Mefluidide	0.14	1.0 c	42.3 d
+ Chlorsulfuron	0.035		
Amidochlor	0.84	43.2 ab	48.1 bc
+ Chlorsulfuron	0.035		
Amidochlor	1.68	40.4 ab	46.1 bd
+ Chlorsulfuron	0.035		
Standard Error		5.6	1.7

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

(Table 59) but was completely ineffective for the suppression of quackgrass seedheads (Table 60). Quackgrass seedhead height was not significantly reduced by any treatment other than Mefluidide and Mefluidide-Chlorsulfuron combinations in 1983 (Table 59). Flurprimidol, Amidochlor, PP-333 and Amidochlor-Chlorsulfuron combination applications reduced Kentucky bluegrass seedhead height by 20 to 48 percent, however, seedheads at these heights and densities (discussed previously, Table 58) were considered unacceptable for a highway roadside.

Clipping yields taken eight weeks after treatment gave trends in yield reduction similar to those of Kentucky bluegrass seedhead inhibition. Applications of Mefluidide, EPTC and Mefluidide-Chlorsulfuron combinations provided the greatest yield reductions (Table 61). Heavy rates of Amidochlor and Amidochlor combined with Chlorsulfuron also reduced yields. All other treatments and rates did not effectively reduce clipping yields. There was no effect on visual color ratings (Table 62).

Interestingly, superior effects were found with most Mefluidide treatments for study DT6 in 1983 (Tables 56 through 62) while in study DT2 for 1983, Mefluidide was essentially not effective (Tables 24 through 32). Treatments were applied 6 May, 1983 for 2DT2 and 9 May, 1983 for 1DT6 yet there is a large difference in their respective responses (compare Tables 24-32 with Tables 56-62). Rainfall records (from Appendix Table 67) reveal that the 1DT6 applications (9 May, 1983) remained on the grass blades for at least five days before being washed off by rain. The 2DT2 treatments (6 May, 1983) were rained on later that same day and throughout the following day. Therefore, the absorption time had been much less than one day for the 2DT2 treatments.

Table 61. 1DT6 and 2DT6 PGR Compound, Rate and Mixture Study-1983 and 1984. Dry weight of clipping yields, mowed at 8.9 cm. Plots treated 6 May, 1983 and 5 May, 1984. Yields in 1983 and 1984 on the dates shown.

Treatment		Dry weight of clipping yields		
Chemical	Rate (kg/ha)	1983	1984	
		1 July (gm)	11 June (gm)	12 July (gm)
Control	-	233 a*	201 ab*	257 ab*
Flurprimidol	1.12	219 ab	139 be	253 ab
Flurprimidol	2.2	208 ac	174 ad	168 ac
Mefluidide	0.28	102 e	63 f	154 bc
Mefluidide	0.42	136 de	55 f	142 c
EPTC	5.6	135 de	122 de	202 ac
EPTC	11.2	145 ce	143 be	160 ac
Amidochlor	1.12	203 ad	160 ae	184 ac
Amidochlor	2.2	156 be	131 de	149 bc
PP-333	1.12	218 ab	195 ac	268 a
PP-333	2.2	212 ac	178 ad	176 ac
Mefluidide	0.07	134 de	137 ce	175 ac
+ Chlorsulfuron	0.035			
Mefluidide	0.14	127 e	110 ef	224 ac
+ Chlorsulfuron	0.035			
Amidochlor	0.84	207 ac	207 a	245 ac
+ Chlorsulfuron	0.035			
Amidochlor	1.68	163 be	143 be	150 bc
+ Chlorsulfuron	0.035			
Standard Error		21.0	19.0	32.0

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 62. IDT6 PGR Compound, Rate and Mixture Study-1983. Visual color quality, 1 to 9 where 1 = yellow and 9 = dark green. Plots treated 6 May, 1983. Evaluated 19 July, 1983.

<u>Treatment</u>		<u>Color quality</u>
<u>Chemical</u>	<u>Rate</u> (kg/ha)	
Control	-	4.8 ab*
Flurprimidol	1.12	4.6 ab
Flurprimidol	2.2	4.3 b
Mefluidide	0.28	5.8 a
Mefluidide	0.42	4.8 ab
EPTC	5.6	5.5 ab
EPTC	11.2	5.0 ab
Amidochlor	1.12	5.0 ab
Amidochlor	2.2	5.4 ab
PP-333	1.12	4.8 ab
PP-333	2.2	4.3 b
Mefluidide	0.07	5.1 ab
+ Chlorsulfuron	0.035	
Mefluidide	0.14	6.0 a
+ Chlorsulfuron	0.035	
Amidochlor	0.84	5.4 ab
+ Chlorsulfuron	0.035	
Amidochlor	1.68	5.0 ab
+ Chlorsulfuron	0.035	
Standard Error		0.4

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Mefluidide is absorbed through the foliage so this differential response can likely be attributed to the difference in PGR leaf contact time. These same circumstances might help explain the different responses found for Amidochlor treatments in these same studies. Because Amidochlor is a crown and/or root absorbed PGR, better results would be expected if the compound were washed into the zone of plant uptake sooner after treatment. If not washed in this class of PGR compound will be subject to microbial decay (from technical information supplied by Monsanto Ag. Prod. Co.) and other environmental deactivation factors which can reduce its effectiveness dramatically.

1984 2DT6

The abnormal heat and drought experienced for the month of June probably contributed to the adverse effects observed on some plots for some treatments. Mefluidide treatments at the low and high rate received excellent quality of control scores (Table 56). These results were by far superior to any other treatment. The next best scores were given to the Mefluidide-Chlorsulfuron combinations especially for the heavier rate. The quality of the control plots gradually declined during the growing season which reduced the statistical significance somewhat. The declining quality scores followed the same trend for both rates of Flurprimidol, EPTC, the light rate of Amidochlor, both rates of PP-333 and both rates of the Amidochlor-Chlorsulfuron combination (Table 56). Vegetative density ratings taken four weeks after treatment showed that both rates of Mefluidide and the Mefluidide-Chlorsulfuron combinations had thinned the turf the most (Table 57). The worst thinning would be considered moderately unsatisfactory. After seven

weeks turf density ratings had not improved for the Mefluidide treatments and EPTC plots were exhibiting similar turf density reductions. Vegetative density ratings for Amidochlor-Chlorsulfuron treatments were unchanged from four weeks to seven weeks. Scores for PP-333, Amidochlor, EPTC and Flurprimidol decreased over the same time period. The hot, dry weather at this time of the season likely contributed to this negative trend.

Excellent seedhead density reductions were found only with Mefluidide at the low and high rate (Table 58). The heavy Mefluidide-Chlorsulfuron combination gave good control while the only other treatments which provided sufficient seedhead inhibition to be considered beneficial were heavy rates of Amidochlor alone or in combination with Chlorsulfuron. All other compounds, rates and mixtures were determined to be ineffective from a practical standpoint. Kentucky bluegrass seedhead height was reduced by 74 percent or more for high and low rates of Mefluidide and EPTC (Table 59). The high rate of Amidochlor shortened bluegrass seedheads by 60 percent. Other rates and treatments gave statistically significant reductions but of marginal value. Complete inhibition of quackgrass seedhead production was found with both rates of Mefluidide (Table 60). The responses from all other treatments were not significantly different from the control.

Clipping yields (Table 61) were taken at five and ten weeks after treatment. Yield reductions at five weeks were excellent for Mefluidide treatments, moderate for EPTC, Mefluidide-Chlorsulfuron, the high rate of Amidochlor, and the high rate of Amidochlor combined with Chlorsulfuron although statistical significance was not always strong. By ten weeks after treatment only Mefluidide at the high rate exhibited

a significant reduction of vegetative yields. High variability reduced the sensitivity of the statistical analyses even though some treatments gave considerably lower yields than the control. It should be noted that some long term vegetative inhibition may be indirectly due to the slow recovery from PGR induced phytotoxic injury or environmental stress (drought in particular) or some combination of the two.

Simulated Highway Roadside PGR Application Study DT7

Selected PGR-herbicide combinations were applied to large sized plots with a sprayer built to deliver 467.5 l/ha through a two tip boom setup. The spray system design, its operating volume and ground speed were carefully designed to simulate as closely as possible liquid application methods used by the Michigan Department of Transportation.

Quality of control ratings were taken at five and ten weeks after treatment (Table 63). All PGR-herbicide combination treatments resulted in improved turf quality on both evaluation dates. Quality ratings for Amidochlor-2,4-D, Amidochlor-Chlorsulfuron and Mefluidide-Chlorsulfuron combinations ranked high on both dates of evaluation. The lowest ratings, regardless of the evaluation date were considered to have produced at least adequate effects for this highway site.

Vegetative density was reduced most by the Amidochlor-Chlorsulfuron-2,4-D treatment (Table 64). All other treatments did not significantly affect the turf density either positively or negatively. For this site the observed vegetative density reduction was not severe enough to suggest that future use of PGRs would be impractical.

Relative seedhead density was significantly reduced from the

Table 63. DT7 Simulated Highway Roadside PGR Application Study-1984.
 Quality of control combining all factors. Visual estimates,
 1 to 9 where 9 = ideal control. Plots treated 16 May, 1984.
 Evaluation dates; 22 June and 26 July, 1984.

Treatment Chemical	Rate (kg/ha)	Quality of control	
		22 June 84	26 July 84
Control	-	3.0 b*	1.3 b*
Amidochlor + 2,4-D	1.68	7.2 a	6.7 a
Amidochlor + Chlorsulfuron	1.68 0.035	7.0 a	7.3 a
Amidochlor + Chlorsulfuron + 2,4-D	1.68 0.023 1.12	5.0 ab	6.7 a
Mefluidide + Chlorsulfuron	0.14 0.035	6.7 a	6.8 a
Mefluidide + Chlorsulfuron + 2,4-D	0.14 0.023 1.12	5.7 ab	5.0 a
Standard Error		1.0	0.9

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 64. DT7 PGR Simulated Highway Roadside PGR Application Study-1984. Vegetative density all species combined. Visual estimates, 1 to 9 where 9 = greatest vegetative density. Plots treated 16 May, 1984. Evaluated 22 June, 1984.

Treatment		Vegetative density
Chemical	Rate (kg/ha)	
Control	-	7.0 a*
Amidochlor	1.68	6.7 ab
+ 2,4-D	1.68	
Amidochlor	1.68	6.3 ab
+ Chlorsulfuron	0.035	
Amidochlor	1.68	5.0 b
+ Chlorsulfuron	0.023	
+ 2,4-D	1.12	
Mefluidide	0.14	6.5 ab
+ Chlorsulfuron	0.035	
Mefluidide	0.14	6.5 ab
+ Chlorsulfuron	0.023	
+ 2,4-D	1.12	
Standard Error		0.4

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Amidochlor-Chlorsulfuron-2,4-D treatments only (Table 65). Although other treatments reduced the relative seedhead density or seedhead production the differences were not significant. Weed population evaluations (Table 66) indicated good weed suppression for most PGR-herbicide combinations. Practical significance of the weed population reductions were seen with all treatments except Amidochlor plus Chlorsulfuron. However, variability among plots was responsible for a complete lack of statistical significance.

This study was primarily performed to determine if standard application methods would have any influence on the consistency of PGR responses. Understandably, the plot sprayer used for other studies gave much more uniform coverage and, more uniform responses and therefore, better data for PGR efficacy. DT7 was successful because the results indicate that large scale application without severe reductions in chemical efficacy can be achieved.

Table 65. DT7 Simulated Highway Roadside PGR Application Study-1984.
 Relative seedhead density all species combined. Visual
 estimates, 1 to 9 where 9 = greatest seedhead density. Plots
 treated 16 May, 1984. Evaluated 26 July, 1984.

<u>Treatment</u>		<u>Relative seedhead density</u>
<u>Chemical</u>	<u>Rate</u> (kg/ha)	
Control	-	5.5 a*
Amidochlor	1.68	3.5 ab
+ 2,4-D	1.68	
Amidochlor	1.68	3.0 ab
+ Chlorsulfuron	0.035	
Amidochlor	1.68	1.8 b
+ Chlorsulfuron	0.023	
+ 2,4-D	1.12	
Mefluidide	0.14	2.5 ab
+ Chlorsulfuron	0.035	
Mefluidide	0.14	4.2 ab
+ Chlorsulfuron	0.023	
+ 2,4-D	1.12	
Standard Error		1.0

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

Table 66. DT7 Simulated Highway Roadside PGR Application Study-1984.
Weed population index. Visual estimates, 1 to 9 where
9 = greatest weed population. Plots treated 16 May, 1984.

<u>Treatment</u>		<u>Weed population index</u>
<u>Chemical</u>	<u>Rate</u> (kg/ha)	
Control	-	5.2 a*
Amidochlor	1.68	2.5 a
+ 2,4-D	1.68	
Amidochlor	1.68	3.5 a
+ Chlorsulfuron	0.035	
Amidochlor	1.68	1.2 a
+ Chlorsulfuron	0.023	
+ 2,4-D	1.12	
Mefluidide	0.14	1.3 a
+ Chlorsulfuron	0.035	
Mefluidide	0.14	1.7 a
+ Chlorsulfuron	0.023	
+ 2,4-D	1.12	
Standard Error		1.2

* Means within columns with like letters do not differ significantly according to Duncan's Multiple Range Test (5%).

CONCLUSIONS

1. The "window of activity" is defined as the time span in calendar weeks during which any particular PGR compounds must be applied for maximum effectiveness. This window varies among grass species, by the mode of absorption and by seasonal weather variations which affect spring growth and seedhead initiation of the plant. The "window of activity" for Mefluidide on the mixed swards used in these studies was: approximately 27 Apr. to 10 May in 1982 (Table 7); approximately 22 Apr. to 15 May in 1983 (Table 10); and, approximately 20 Apr. to 17 May in 1984 (Tables 10 and 19). The data suggest that very early applications can severely inhibit normal spring green-up and that once the peak period for seedhead initiation has passed, further PGR applications have dramatically reduced effects for turf quality improvements. It is likely that applications three to four days before or after these dates would have given equally effective results, however, there is no actual data to support such a claim. The "window of activity" for Amidochlor was: approximately 27 Apr. to 25 May in 1982 (Table 7); approximately 22 Apr. to 15 May in 1983 (Table 10); and, approximately 20 Apr. to 17 May in 1984 (Tables 10 and 19).

2. The timing of seedhead initiation varies among grass species, therefore, the timing of PGR compound application is critical for seedhead suppression of specific grasses. The "window of activity" for PGR treatment of a mixed stand can, therefore, be difficult to determine. No data were gathered for the exact beginning date of seedhead initiation for individual species. However, non-statistical observations would characterize seedhead initiation periods for central lower Michigan as follows: Kentucky bluegrass and fine fescue, from early to mid May; orchardgrass, tall fescue, smooth brome grass and quackgrass, from mid to late May; and redtop and perennial ryegrass, from late May to early or mid June.

3. Most grass vegetation lodges once it reaches a certain height, therefore, any vegetative growth which occurs after the grass has lodged has very little effect on the appearance of utility grass sites. When uncontrolled, seedhead height and seedhead density are the primary factors responsible for the low aesthetic quality of highway roadsides. Weeds and woody plants also detract from utility site aesthetics but these plants require separate chemical controls.

4. Most of the PGRs tested were found to be somewhat species specific. For example, on fine-textured species such as Kentucky bluegrass and fine fescue excellent seedhead suppression resulted from PGR treatment while coarser-textured grasses such as brome grass, tall fescue, and orchardgrass were less consistently affected by a given compound and rate. Phytotoxic injury was also somewhat species specific. Chlorsulfuron caused severe injury to tall fescue even at very low

rates.

5. The appropriate rate of application for certain PGR compounds was critical. Careful attention is required when applying Mefluidide because over treatment can cause severe injury and under treatment may result in unsatisfactory control for practical use on highway turfs. EPTC also resulted in severe turf discoloration at the higher rates of application. Low EPTC rates also caused discoloration although not as severe. Amidochlor had a greater margin for safe use, over treatment did not result in severe discoloration but under treatment was significantly less effective than optimum rates.

6. Mowing energy requirements were modestly reduced by PGR suppression of vegetative growth and seedhead production of desired species, however, currently available PGRs will not likely eliminate all mowing needs.

7. Seedhead suppression of cool season grasses is the only form of season long control produced by the PGR treatments used in these studies. Season long vegetative control was not observed for any PGR treatment. Severe phytotoxic injury can result in long term vegetative reductions but the appearance of the site may be unsatisfactory.

8. Several PGR treatments produced color enhancement of the treated turf. Improved green color is considered to be a positive aesthetic effect at any level of turfgrass maintenance. In general the PGRs given superior overall ratings also resulted in improved green color. Reduced

seedhead production and delayed senescence of leaf tissue contributed to the perception of color enhancement of the treated plots by reducing the accumulation of straw or brown colored tissue (sometimes referred to as "trash"). Watschke (72) and Kaufmann (47) suggested that some PGRs cause increased chlorophyll production and accumulation of carbohydrates in living turf foliage which would also result in color enhancement.

9. Prevailing weather conditions affected the efficacy of the PGRs evaluated in these studies. The duration of PGR leaf contact time is very important for foliarly absorbed compounds such as Mefluidide. Rainfall soon after treatment with a foliarly absorbed PGR will dramatically reduce the efficacy of that compound due primarily to reduced leaf contact time. On the other hand, the efficacy of crown and/or root absorbed compounds such as Amidochlor, Flurprimidol and Chlorsulfuron is enhanced if rainfall occurs during or soon after application. This type of compound must be washed into the zone where plant uptake occurs in order to be effective. If crown and/or root absorbed compounds are left on the grass leaves too long they are subject to microbial decay and other environmental deactivation factors which reduce their effectiveness significantly.

10. Many utility turf sites are subject to significant weed encroachment pressure. PGR treatments which cause excessive turf thinning and greatly reduced turf vigor will increase the potential for weed encroachment. In addition, PGR treated turfs have increased disease susceptibility and on sloped sites the potential for soil erosion is increased.

11. Fall application of PGRs did not provide satisfactory response the following spring. No carry-over effects from spring or fall applications were observed from one year to the next for any study. Little or no cumulative turf thinning was observed for repeated annual PGR applications.

APPENDIX

Table 67. Dates of treatment for each year of study followed by the date and amount of rainfall following each treatment.

Study	Date of Application	Date of Rainfall	Amount of Rainfall
1DT1 1982	27 Apr	5 May	0.78
	10 May	12 May	0.38
	25 May	27 May	1.12
	17 June	19 June	1.52
2DT1 1983	22 Apr	28 Apr	2.21
	4 May	7 May	0.07
		8 May	0.43
	15 May	19 May	0.75
3DT1 1984	27 May	29 May	0.28
	25 Apr	26 Apr	0.03
		27 Apr	0.06
	6 May	9 May	0.07
DT1B 1984		13 May	0.52
	12 May	13 May	0.52
	24 May	25 May	0.79
	20 Apr	22 Apr	0.30
	2 May	2 May	0.10
		5 May	0.07
	10 May	13 May	0.52
	17 May	18 May	0.07
		22 May	1.35
	31 May	5 June	0.17
1DT2 1982	8 May	12 May	0.38
2DT2 1983	6 May	7 May	0.43
3DT2 1984	10 May	13 May	0.52
DT3 1982	16 Oct	31 Oct	1.22
	25 Oct	31 Oct	1.22
	16 Nov	26 Nov	0.51
	1 Dec	1 Dec	0.25
		3 Dec	2.36
1-4 DT4 1983	17 May	19 May	0.75
5-8 DT4 1983	18 May	19 May	0.75
1-8 DT4 Dry 1983	20 May	22 May	0.61
1-8 DT4 1984	15 May	17 May	Irrigated
1-8 DT4 Dry 1984	16 May	17 May	Irrigated
1DT5 1983	11 May	14 May	0.08
		19 May	0.75
		18 May	0.07
2DT5 1984	14 May	22 May	1.35
		6 May	0.07
		7 May	0.43
2DT6 1984	5 May	9 May	0.07
		13 May	0.52
		18 May	0.07
DT7 1984	16 May	22 May	1.35

Table 68. PCR compound, formulation, chemical name and manufacturer.

Product:	Cutless ^R (Flurprimidol)
Formulation:	50% wettable powder
Chemical name:	α -(1-Methylethyl)- α - [4-trifluoromethoxy) phenyl]-5-pyrimidine methanol
Manufacturer:	Eli Lilly and Company, Indianapolis, IN 46285
Product:	Embark ^R (Mefluidide)
Formulation:	2S
Chemical name:	N-[2,4-dimethyl-5-[[trifluoromethyl) sulfonyl] amino] phenyl] acetamide
Manufacturer:	3M Company, Agricultural Products Division, St. Paul, MN 55144
Product:	MBR-18337 (no longer available for investigation)
Formulation:	2 EC
Chemical name	(N-4-ethylthio)-2-(trifluoromethyl)phenyl methanesulfonamide
Manufacturer:	3M Company, Agricultural Products Division, St. Paul, MN 55144
Product:	Eptam ^R (EPTC)
Formulation:	5G or 10G
Chemical name:	5-Ethyl dipropylthiocarbamate
Manufacturer:	Stauffer Chemical Company, Agricultural Chemical Division, Omaha, NE 68114
Product:	Limit ^R (Amidochlor)
Formulation:	4 lb. flowable
Chemical name:	N-[(acetyl amino) methyl]-2-chloro-N-(2,6-diethylphenyl)
Manufacturer:	Monsanto Agricultural Products Company, 800 N. Lindbergh Blvd., St. Louis, MO 63166
Product:	PP-333
Formulation:	50% wettable powder
Chemical name:	(2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-1,2,4-triazol- 1-yl-) pentan-3-ol
Manufacturer:	ICI Americas Inc., Agricultural Chemicals Division, P.O. Box 208, Goldsboro, NC 27530
Product:	Telar ^R (Chlorsulfuron)
Formulation:	75% dry flowable
Chemical name:	2-chloro-N-[(4-methox-6-methyl-1,3,5-triazin-2-yl) amino carbonyl] benzenesulfonamide
Manufacturer:	The DuPont Company, Agricultural Chemicals Department, Wilmington, DE 19898

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