CHAPTER III

APPLICATION OF FLURPRIMIDOL AND PACLOBUTRAZOL TO TWO DIFFERENT TURFGRASS SITES

Site A. Effect of Growth Regulators, Traffic, GA_3 and Urea on a Fine Fescue Golf Course Rough

Reason for Experimentation

Growth retardants could play an important role in the maintenance of golf course rough by reducing mowing requirements. Golf cart traffic restricted to these areas often results in damaged turf due to the direct effects of turfgrass wear. Turf areas treated with growth regulators may be predisposed to injury due to reduced recuperative potential (Beard, 1973). Chemical or cultural practices which counteract growth suppression would be beneficial in promoting stress recovery.

GA_3 has been shown to reverse the growth retardation effects of ancymidol and flurprimidol on greenhouse grown plants (Soolbaugh and Hamilton, 1976; Shive and Sisler, 1976; Kane and Smiley, 1983). Urea has also been observed to stimulate growth of Kentucky bluegrass treated with flurprimidol and paclobutrazol (Watschke, 1982). These 2 practices were used to determine whether they would stimulate the stress recovery of fine fescue treated with growth retardants.

Seedhead inhibition of Kentucky bluegrass has been achieved by adding small quantities of mefluidide to flurprimidol and paclobutrazol

(Jagshitz, 1981). No studies have reported the effect of MBR-18337 (3M Company) in combination with flurprimidol and paclobutrazol. MBR-18337 is a known seedhead inhibitor with mefluidide-like properties (Wehner, 1980).

Therefore the specific objectives of this study were:

1. To compare the effects of mefluidide, MBR-18337, flurprimidol, and paclobutrazol applied alone and in combination on a fine fescue golf course rough.
2. To observe the response of treated fine fescue to cart traffic.
3. To assess the effectiveness of GA_3 and urea in antidoting the growth suppression effects of fine fescue.

Materials and Methods

Experimental Site and Growth Regulator Application

This study was conducted at The Pennsylvania State University Blue Golf Course on a Pennlawn red fescue (Festuca rubra) rough located between fairways 14 and 15. The soil was a Hagerstown silt loam (fine, mixed, mesic Hapludalf). Plots measuring 25 m^2 were treated on 24 June 1980, 19 May 1981, and 28 June 1982 with the following materials: Mefluidide 2S or MBR-18337 2EC at 0.28 kg/ha, flurprimidol 50W or paclobutrazol 50W at 1.68 kg/ha, flurprimidol 50W at 0.84 kg/ha in combination with either mefluidide 2S or MBR-18337 2EC at 0.06 kg/ha, or paclobutrazol 50W at 0.84 kg/ha in combination with either mefluidide 2S or MBR-18337 2EC at 0.06 kg/ha. Treatments were replicated 3 times.

Applications were made with a Smithco® boom type sprayer mounted on a Toro® workmaster that was calibrated to deliver 561 l/ha. This sprayer was routinely used for golf course maintenance and is representative of equipment commonly available for growth regulator applications. DCPA (dimethyl tetrachlorophthalate) at 11.2 kg/ha was applied in May 1982 for annual grass control prior to growth regulator treatments.

Traffic

For 4 weeks in 1980 (27 July-21 August) and in 1981 (29 June-24 July) and 2 weeks in 1982 (5 July-19 July) a 3-wheeled electric golf cart was used to impose traffic across the plots in a split block design in 3 regimes: high, low and none. The high regime consisted of 30 passes a week in 1980, 42 passes a week in 1981, and 60 passes a week in 1982. The low regime was half the amount of traffic of the high regime. Traffic was divided equally on a Monday, Wednesday, and Friday schedule.

Mowing Protocol

Weekly mowing in 1980, at a 6 cm height, was suspended at 1 week after application and discontinued until data were collected for that year. In 1981, plots were mowed normally on a weekly schedule prior to applications, and then mowed at 5 cm 2½ weeks later to remove seedheads that appeared in some of the plots. In 1982, the area was mowed at 5 cm at 5 days after application and mowed at 5 cm whenever individual plots exceeded 7.5 cm in 2 out of 3 replications. This mowing protocol in 1982 was conducted until 27 July when plots were mowed weekly at 6 cm to accommodate antidotal applications.

Antidotal Applications

After the 2-week traffic period in 1982 (19 July), the plots were subdivided and treated with GA_3, urea, or GA_3 + urea antidotal applications. A fourth section in each plot served as a non-antidoted check. GA_3 was applied in Gibrel Powder® (5% gibberellic acid, Merk Chemical Division, Rahway, NJ) at the rate of 105 g/ha in 100. ppm aqueous solution. Urea was applied at the rate of 108 kg/ha. Supplemental irrigation was given following these applications. That evening a heavy rainfall occurred. Weekly mowing at 6 cm was initiated 8 days after this time.

Data Collection

Data collection in 1980 and 1981 during a 12-week period following application consisted of canopy height measurements and color ratings. Canopy heights were measured 5 times in 1980 and 7 times in 1981 according to the procedure described in Experiment 1. Color ratings were made 5 times in 1980 and 7 times in 1981 on a 1 to 9 scale. A plot which rated a "1" was brown in color with no green turfgrass foliage. A plot which rated a "9" was dark green in color. Seedhead inhibition was observed visually in 1981 at 2.5 weeks after application.

In 1982, mowing schedules for individual plots were recorded for 4 weeks after treatment. Canopy heights were measured at 8 and 11 days after antidotal applications. Color ratings were made 3 times prior to and 3 times after antidotal applications.

Results and Discussion

Growth Regulation and Color Ratings in 1980

Canopy heights and color ratings for the plots did not differ among the different chemical treatments. Traffic, however, did result in a combed (i.e., free of yellow foliage and litter) appearance and color ratings were uniformly higher in the trafficked areas. This type of traffic pattern is commonly seen along the margins of many golf course roughs. The lack of significant differences among growth regulator applications was attributed to the low rainfall after application and the resulting slow growth of the fescue (see weather data in Appendix Fig. 17).

Growth Regulation in 1981

A comparison of the fescue canopy at 3 weeks after application of growth regulators showed that mefluidide and MBR-18337 plots caused the shortest, paclobutrazol intermediate, and flurprimidol the tallest turf (Fig. 14A, Appendix Table 40). Other researchers have found mefluidide and MBR-18337 to be quick acting on the growth of Kentucky bluegrass (Wehner, 1980; Watschke, 1981). After 3 weeks, mefluidide treated turf grew steadily and canopy height increased. Flurprimidol and mefluidide did not control growth beyond the 6.5 week period. MBR-18337 resulted in a longer period of suppression than mefluidide without rapid growth after the growth regulator effects subsided. Paclobutrazol caused the longest suppression period with little vertical shoot growth until 10 weeks after application. Watschke (1981) found

paclobutrazol to be more persistent than flurprimidol when applied to Kentucky bluegrass turf.

The effect of paclobutrazol + mefluidide on turf height was more dramatic than with the other combinations (Fig. 14B; Appendix Table 40). Vertical shoot growth of grass treated with paclobutrazol + mefluidide was negligible for 6.5 weeks, but then grew rapidly thereafter. All other combinations were similar in effectiveness for growth control and had little influence after 6.5 weeks.

Color Ratings in 1981 in Non-Traffic Areas

By comparison, MBR-18337 caused the most discoloration at 5 weeks after application, as shown by the color ratings in Fig. 15 (Appendix Table 41), although color of these plots improved after 6.5 weeks. Turf response to mefluidide mimicked MBR-18337 although discoloration was not as severe. Color ratings differed from paclobutrazol treated plots, which had a high color rating initially, but declined steadily until 9 weeks after application when color improved. Flurprimidol treated grass had a consistently high color rating throughout 1981. Combination treatments caused equivalent injury for the first 6.5 weeks after application, but by week 8 discoloration was more apparent on turf treated with flurprimidol + MBR-18337 or paclobutrazol + MBR-18337 than flurprimidol + mefluidide or paclobutrazol + mefluidide (Fig. 16; Appendix Table 41).

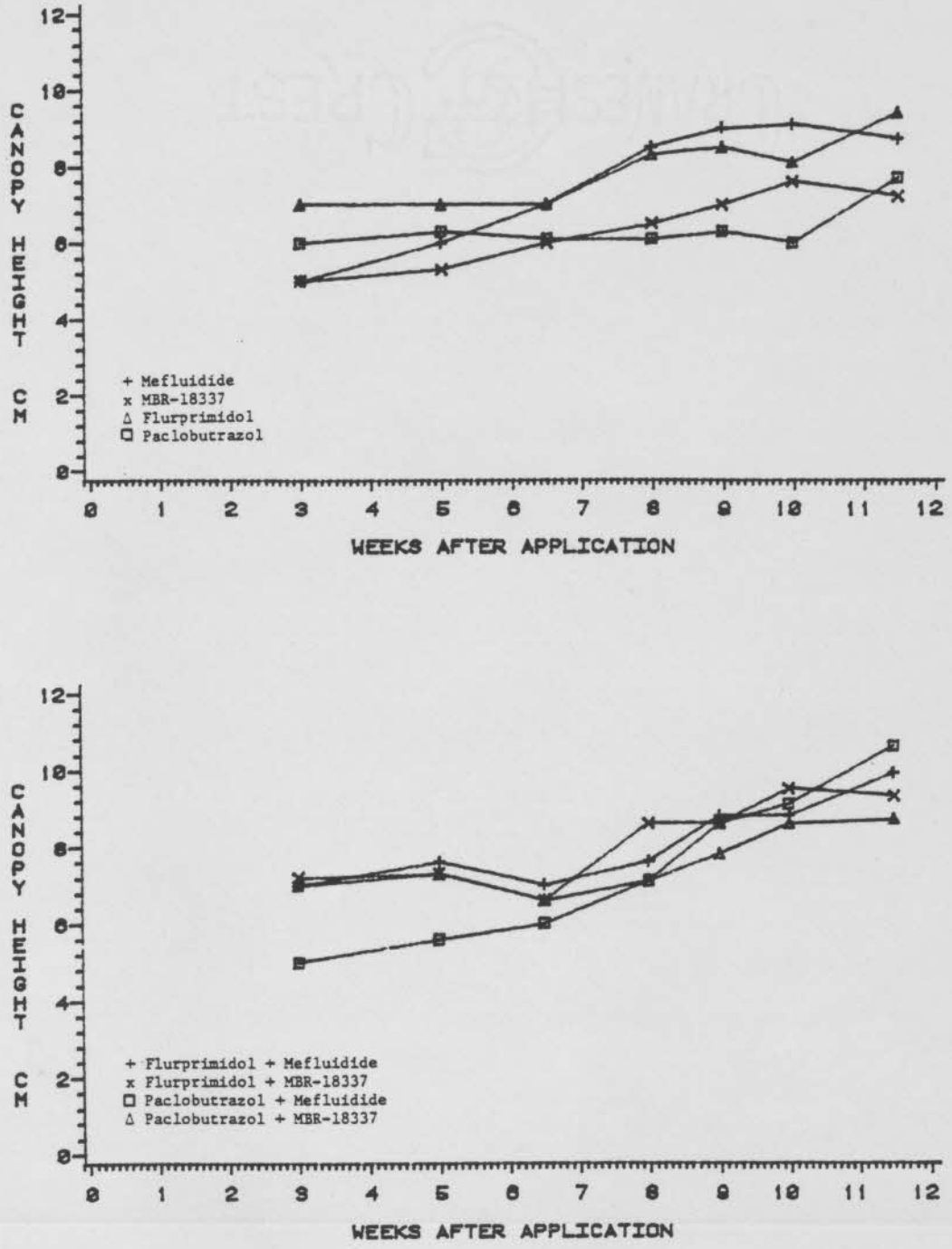

Fig. 14. Effect of growth regulators on the canopy height of fine fescue at various dates after a 19 May 1981 application.

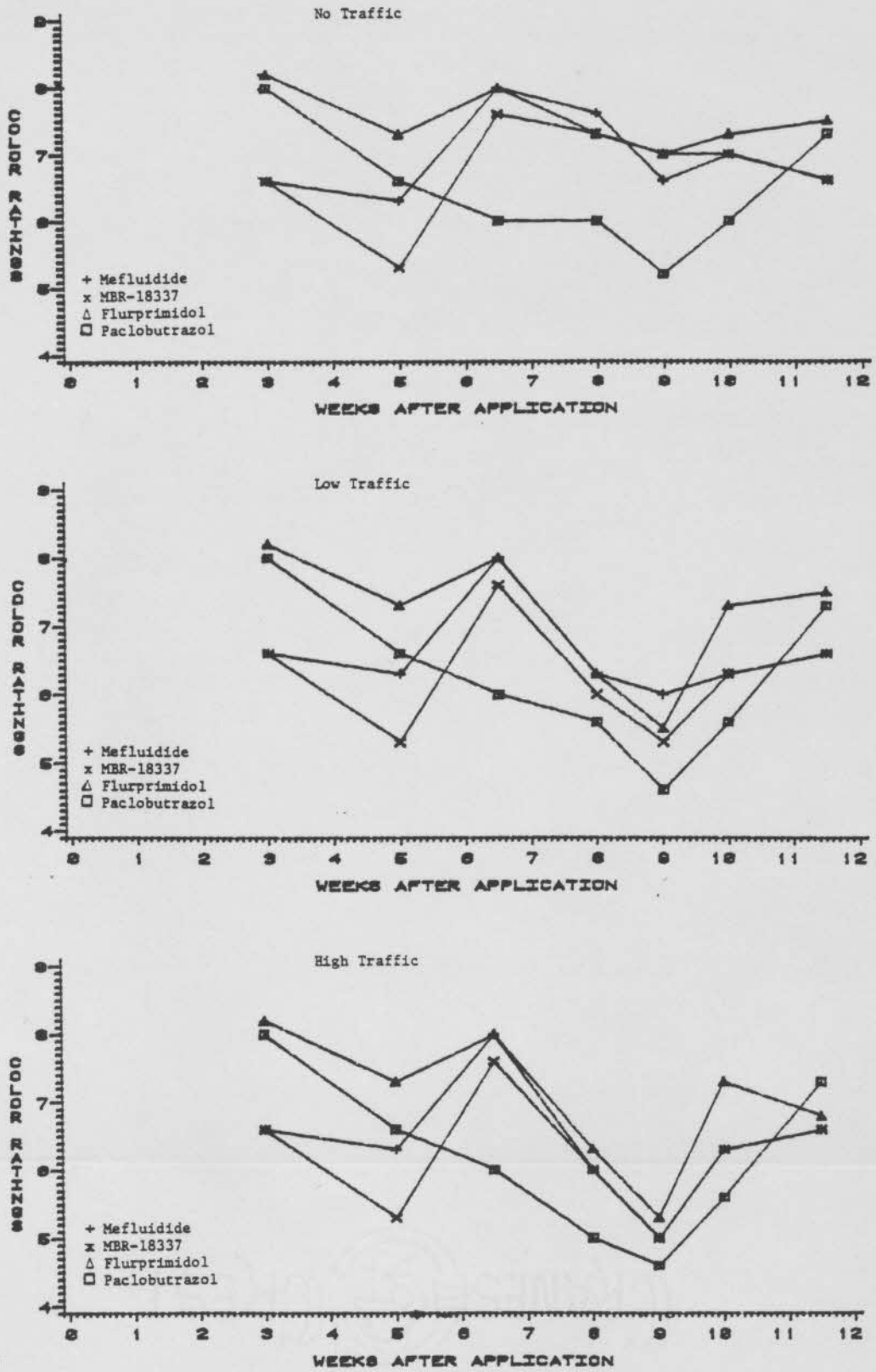

Fig. 15. Effect of growth regulators on the color ratings of fine fescue subjected to traffic at various dates after a 19 May 1981 application.

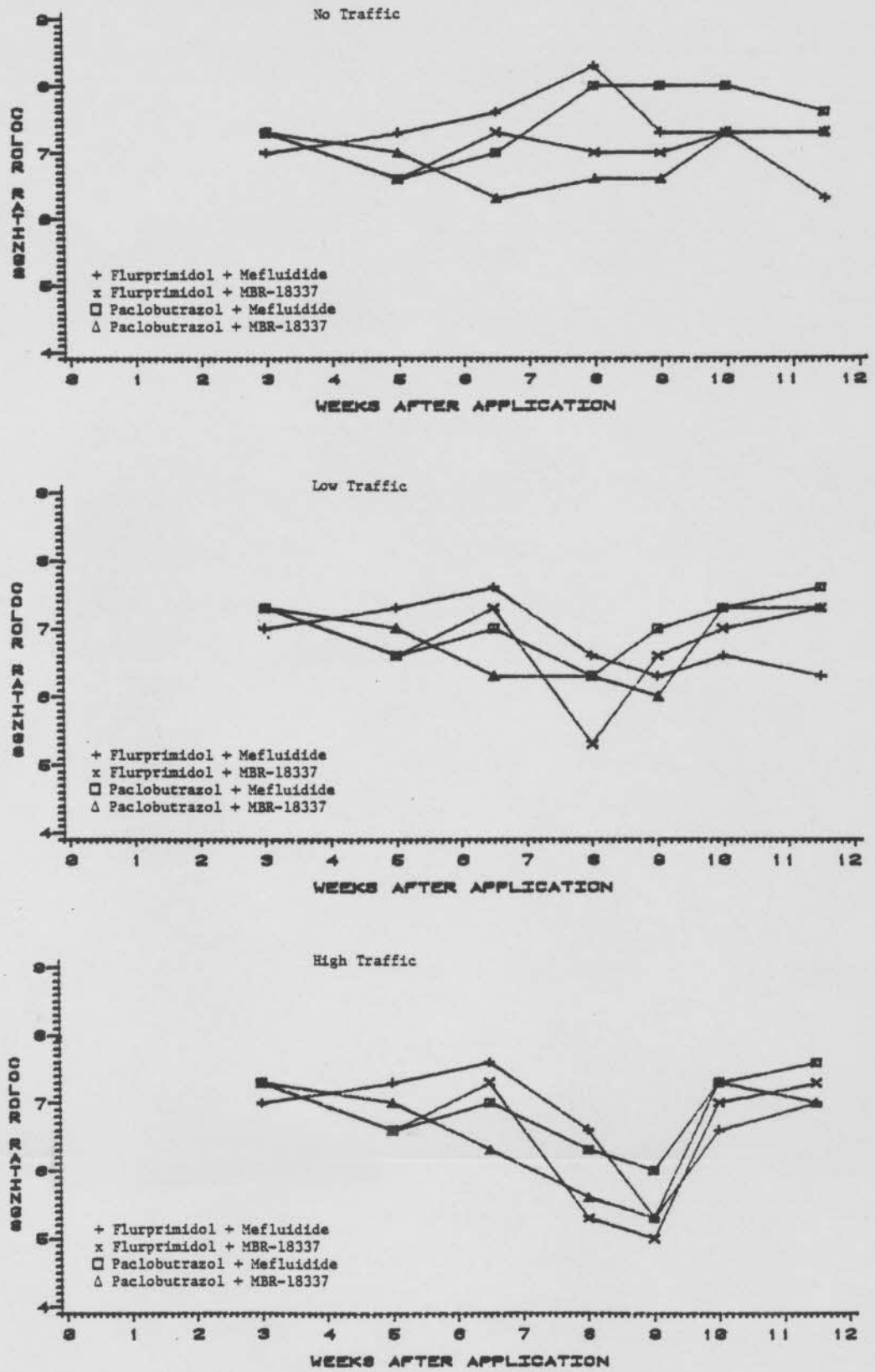

Fig. 16. Effect of growth regulator mixtures on the color ratings of fine fescue subjected to traffic at various dates after a 19 May 1981 application.

Traffic in 1981

Damage from traffic was significant and resulted in very low color ratings at 9 weeks after application (Figs. 15 and 16; Appendix Table 41). High traffic masked treatment differences, but paclobutrazol treated grass was more injured than other grass. Under the low traffic regime, color for mefluidide-treated plots was higher than paclobutrazol treated plots. High traffic on the combination treatments also minimized color differences between the plots. Under low traffic, turf response to the combinations was similar to the mefluidide application with less discoloration than that associated with paclobutrazol.

Seedhead Suppression

Since neither flurprimidol and paclobutrazol inhibited seedhead development, these plots were used as checks to compare suppression with that in other treatments (Table 13).

Table 13. Influence of Growth Regulators on the Seedhead Emergence of Fine Fescue 2.5 Weeks After Application.

Growth Regulator	Rate kg/ha	Seedhead Suppression %
Mefluidide 2S	0.28	95.0 a*
MBR-18337 2EC	0.28	91.6 a
Flurprimidol 50W	1.68	0.0 d
Paclobutrazol 50W	1.68	0.0 d
Flurprimidol + Mefluidide	0.84 + 0.06	78.3 b
Flurprimidol + MBR-18337	0.84 + 0.06	58.3 c
Paclobutrazol + Mefluidide	0.84 + 0.06	81.6 b
Paclobutrazol + MBR-18337	0.84 + 0.06	63.3 c

*Values with a letter in common do not differ at the 5% level of probability using Duncan's Multiple Range Test.

Both Mefluidide and MBR-18337 successively inhibited seedhead formation. Combinations were not as effective as mefluidide and MBR-18337 in reducing seedhead formation. Mefluidide combination treatments caused greater seedhead inhibition than MBR-18337 combination treatments.

Mowing Schedule and Pre-Antidotal Color Ratings in 1982

In 1982, mefluidide, MBR-18337, flurprimidol + MBR-18337, and paclobutrazol + mefluidide decreased the mowing schedule of fine fescue more than the other treatments. Mefluidide and MBR-18337 produced more injury than flurprimidol or paclobutrazol immediately after application (Table 14).

Table 14. Color Ratings and Mowing Schedule of Fine Fescue After Application of Growth Regulators and Traffic.

Treatment	Rate kg/ha	Color Ratings Weeks after Application 1.5	2.3	3	No. of Mowings in 4 Weeks
Mefluidide 2S	0.28	6.6 b*	5.1 cd	4.6 bc	1
MBR-18337 2EC	0.28	6.6 b	4.5 d	4.1 c	1
Flurprimidol 50W	1.68	8.4 a	7.1 ab	7.7 a	2
Paclobutrazol 50W	1.68	8.0 a	7.0 ab	6.1 a-c	2
Flurprimidol + Mefluidide	0.84 + 0.06	7.4 ab	6.9 ab	5.5 bc	2
Flurprimidol + MBR-18337	0.84 + 0.06	6.6 b	5.6 b-d	4.9 bc	1
Paclobutrazol + Mefluidide	0.84 + 0.06	7.2 ab	6.8 ab	6.3 ab	1
Paclobutrazol + MBR-18337	0.84 + 0.06	7.2 ab	6.4 ab	5.5 bc	2

*Values in the same column with a letter in common do not significantly differ using the Duncan's Multiple Range Test.

Flurprimidol + MBR-18337 also produced turf injury. This combination treatment was also injurious in 1981. Color ratings declined throughout the 2-week traffic period that was started 1 week after application. Stress symptoms were most severe in plots treated with mefluidide, MBR-18337, or flurprimidol + MBR-18337, which were rated below 5 at 3 weeks after application. Traffic also decreased color ratings (Table 15).

Table 15. Color Ratings of Fine Fescue Subjected to Traffic and Treated With Growth Regulators.

	Color Ratings Weeks After Application		
Traffic Regime	1.5	2.3	3
No Traffic	7.5 a*	7.1 a	7.2 a
Low Traffic	7.2 b	6.1 b	5.6 b
High Traffic	7.1 b	5.4 c	4.0 c

*Values in the same column with a letter in common do not significantly differ using Duncan's Multiple Range Test.

Turfgrass Antidotal Response

Canopy height measurements and color ratings, made 8 and 11 days after antidotal applications, showed that urea did not stimulate shoot growth, but did improve color (Table 16). The greatest color improvement occurred on plots that were previously treated with MBR-18337 and paclobutrazol.

GA_3 antidotal applications increased canopy heights of all plots when observed 8 days after application (Table 17). The range of canopy height increase was from 14% for MBR-18337 treated plots to 31%

Table 16. Effect of Urea on the Canopy Height and Color Ratings of Fine Fescue Previously Treated With Growth Regulators in 1982.

Treatment	Urea kg/ha	Canopy Height: Days After Urea Application 8 cm	Canopy Height: Days After Urea Application 11 cm	Color Rating: Days After Urea Application 8	Color Rating: Days After Urea Application 11
Mefluidide 2S	0	9.3 a*	6.8 a+	6.6 b	6.8 b
	108	9.1 a	6.5 a	7.3 b	7.8 b
MBR-18337 2EC	0	7.2 a	6.8 a	5.3 a	4.5 b
	108	7.0 a	7.0 a	5.8 a	6.6 a
Flurprimidol	0	8.2 a	7.3 a	7.9 b	7.8 b
	108	8.3 a	7.6 a	8.3 a	8.4 a
Paclobutrazol	0	7.6 a	6.5 a	6.4 b	5.5 b
	108	7.7 a	6.8 a	8.3 a	8.4 a
Flurprimidol + Mefluidide	0	8.7 a	7.2 a	6.9 b	7.3 a
	108	9.2 a	7.5 a	8.4 a	8.0 a
Flurprimidol + MBR-18337	0	7.4 a	6.4 a	6.0 a	6.7 b
	108	7.2 a	6.3 a	6.7 a	7.8 a
Paclobutrazol + Mefluidide	0	7.6 a	6.3 a	6.1 b	6.3 b
	108	7.9 a	6.6 a	7.8 a	7.8 a
Paclobutrazol + MBR-18337	0	7.3 a	6.2 b	6.4 b	6.5 b
	108	8.0 a	7.2 a	7.5 a	7.6 a

*Values within treatments in the same column with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

+Values in this column represent the regrowth of grass from a 6 cm mowing at 8 days after antidotal applications.

Table 17. Effect of GA_3 on the Canopy Height and Color Ratings of Fine Fescue Previously Treated With Growth Regulators in 1982.

Treatment	GA_3 g/ha	Canopy Height: Days After GA_3 Application 8 cm	Canopy Height: Days After GA_3 Application 11 cm	Color Rating: Days After GA_3 Application 8	Color Rating: Days After GA_3 Application 11
Mefluidide 2S	0	9.3 b*	6.8 b+	6.6 b	6.8 a
	105	11.3 a	7.8 a	7.4 a	6.8 a
MBR-18337 2EC	0	7.2 b	6.8 a	5.3 a	4.5 a
	105	8.2 a	5.8 b	6.0 a	4.3 a
Flurprimidol 50W	0	8.2 b	7.3 b	7.9 a	7.8 a
	105	10.8 a	8.4 a	8.1 a	7.7 a
Paclobutrazol 50W	0	7.6 b	6.5 b	6.4 b	5.5 b
	105	9.0 a	8.0 a	7.5 a	7.0 a
Flurprimidol + Mefluidide	0	8.7 b	7.2 b	6.9 b	7.3 a
	105	11.1 a	8.3 a	7.7 a	7.5 a
Flurprimidol + MBR-18337	0	7.4 b	6.4 b	6.0 a	6.7 a
	105	8.7 a	7.3 a	6.7 a	6.5 a
Paclobutrazol + Mefluidide	0	7.6 b	6.3 b	6.1 b	6.3 b
	105	10.0 a	7.7 a	7.8 a	8.0 a
Paclobutrazol + MBR-18337	0	7.3 b	6.2 b	6.4 b	6.5 b
	105	9.2 a	7.5 a	7.8 a	7.3 a

*Values within treatments in the same column with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

+Values in this column represent the regrowth of grass from a 6 cm mowing at 8 days after antidotal applications.

for paclobutrazol+MBR-18337 treated plots. GA_3 also either improved or tended to improve color at 8 days.

Eleven days after application, GA_3 continued to stimulate turf growth except for MBR-18337 treatments. GA_3 applied to MBR-18337 plots lessened regrowth and turf was 11% less than non-antidoted turf. Turf color ratings, at 11 days after application, were not elevated in all GA_3 antidoted plots. Only GA_3 applications to plots treated with paclobutrazol (alone or in combination) had higher color ratings than non-antidoted turf.

GA_3 + urea stimulated foliar shoot growth in all treatments when canopy height was measured 8 days after application (Table 18). This increase in height ranged from 13% for MBR-18337 plots to 54% for paclobutrazol + MBR-18337 plots. GA_3 + urea also improved turf color at 8 days after application.

Eleven days after antidotal application, GA_3 + urea continued to stimulate the growth of all treated plots with the exception of those plots previously treated with mefluidide and MBR-18337. Regrowth of MBR-18337 treated grass was reduced by GA_3 + urea. Turf color ratings of all plots at 11 days after application was improved by GA_3 + urea with the exception of mefluidide treated plots.

Color ratings at 19 days after antidotal applications showed the continued influence of GA_3 + urea and urea antidotes on color improvement (Table 19). Plots treated with GA_3 + urea or urea maintained acceptable color at 7.8 to 8.0, while GA_3, had no effect. This indicated that the urea component in the GA_3 + urea was apparently responsible for this color improvement.

Table 18. Effect of GA_3 + Urea on the Canopy Height and Color Ratings of Fine Fescue Previously Treated With Growth Regulators in 1982.

Treatment	GA_3 + Urea g/ha kg/ha	Canopy Height: Days After GA_3 + Urea Application 8 cm	Canopy Height: Days After GA_3 + Urea Application 11 cm	Color Rating: Days After GA_3 + Urea Application 8	Color Rating: Days After GA_3 + Urea Application 11
Mefluidide 2S	0 + 0	9.3 b*	6.8 a+	6.6 b	6.8 a
	105 + 108	10.8 a	7.1 a	7.7 a	6.7 a
MBR-18337 2EC	0 + 0	7.2 b	6.8 a	5.3 b	4.5 b
	105 + 108	8.3 a	6.0 b	6.8 a	5.6 a
Flurprimidol 50W	0 + 0	8.2 b	7.3 b	7.9 b	7.8 b
	105 + 108	11.8 a	9.2 a	8.7 a	8.4 a
Paclobutrazol 50W	0 + 0	7.6 b	6.5 b	6.4 b	5.5 b
	105 + 108	9.3 a	8.6 a	8.5 a	8.0 a
Flurprimidol + Mefluidide	0 + 0	8.7 b	7.2 b	6.9 b	7.3 b
	105 + 108	12.6 a	9.0 a	8.5 a	8.7 a
Flurprimidol + MBR-18337	0 + 0	7.4 b	6.4 b	6.0 b	6.7 a
	105 + 108	9.3 a	7.3 a	8.0 a	7.3 a
Paclobutrazol + Mefluidide	0 + 0	7.6 b	6.3 b	6.1 b	6.3 b
	105 + 108	9.8 a	8.1 a	8.8 a	8.5 a
Paclobutrazol + MBR-18337	0 + 0	7.3 b	6.2 b	6.4 b	6.5 b
	105 + 108	11.3 a	7.9 a	8.5 a	8.7 a

*Values within treatments in the same column with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

+Values in this column represent the regrowth of grass from a 6 cm mowing at 8 days after antidotal applications.

Table 19. Effect of Different Antidotal Applications on the Subsequent Color Ratings 19 Days After Being Applied to Fine Fescue Previously Treated with Growth Regulators and Subjected to Cart Traffic.

Antidotal Application	Color Rating
GA_3	7.3 b*
GA_3 + Urea	7.8 a
Urea	8.0 a
No Antidote	6.8 b

*Values with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

Post-Traffic Recovery in 1982

Post-traffic recovery was influenced by the degree of traffic. Canopy heights at 8 days after antidotal applications were less in high trafficked areas (Table 20). This difference was a minor actual length (0.4 cm) and difficult to discern. Color ratings were more indicative of stress recovery, especially for turf exposed to high trafic (Table 21). In this case, grass not antidoted was rated 5.7, but when antidoted with GA_3 or urea color improved and approached an acceptable level (7.0). GA_3 + urea applications improved color to an acceptable level of 7.6. This type of turf regeneration in 8 days would warrant the use of GA_3 + urea when it becomes necessary to restore the aesthetic quality of traffic stressed turf previously treated with growth retardants.

Table 20. Canopy Height of Fine Fescue Treated with Growth Regulators 8 Days after Antidotal Applications and Cessation of Different Traffic Regimes.

Regime	Canopy Height cm
No Traffic	9.2 a*
Low Traffic	9.1 ab
High Traffic	8.8 b

*Values with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

Table 21. Color Ratings of Fine Fescue Treated with Growth Regulators 8 Days after Antidotal Applications and the Cessation of Traffic.

Antidotal Applications	Color Ratings		
	Traffic Regimes		
	None	Low	High
GA_3	7.6 b*	7.4 b	7.1 b
GA_3 + Urea	8.6 a	8.3 a	7.6 a
Urea	7.8 b	7.5 b	6.7 b
No Antidote	7.1 c	6.5 c	5.7 c

*Values in the same column with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

Eleven days after antidotal applications, canopy heights of non-trafficked plots treated with flurprimidol were taller than that with MBR-18337, paclobutrazol, flurprimidol + MBR-18337, or paclobutrazol + MBR-18337 (Table 22). Under the low traffic regime, turf was tallest when treated with flurprimidol, paclobutrazol, and flurprimidol + mefluidide. Under high traffic, flurprimidol treated turf was taller than that treated with mefluidide, MBR-18337, or flurprimidol + MBR-18337.

Table 22. Turf Canopy Height at 11 Days After Antidotal Applications.

Treatment	Rate kg/ha	Canopy Height (Traffic Regimes) None cm	Low cm	High cm
Mefluidide 2S	0.28	7.6 a-c*	6.9 b	6.7 bc
MBR-18337 2EC	0.28	6.7 d	6.4 b	6.1 c
Flurprimidol 50W	1.68	8.1 a	8.0 a	8.3 a
Paclobutrazol 50W	1.68	7.0 cd	8.0 a	7.3 a-c
Flurprimidol + Mefluidide	0.84 + 0.06	7.8 ab	8.1 a	7.9 ab
Flurprimidol + MBR-18337	0.84 + 0.06	7.3 b-d	6.5 b	6.7 bc
Paclobutrazol + Mefluidide	0.84 + 0.06	7.4 a-d	7.1 b	7.0 a-c
Paclobutrazol + MBR-18337	0.84 + 0.06	7.0 b-d	7.1 b	7.4 a-c

*Values in the same column with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

Color ratings at 11 days, showed the residual effect of traffic on the experimental area (Table 23). Color continued to be lower in high traffic areas but was not as poor where there was low traffic.

Table 23. Color Ratings of Fine Fescue Treated with Growth Regulators 11 Days after Antidotal Applications and the Cessation of Traffic.

Regime	Color Ratings
No Traffic	7.6 a*
Low Traffic	7.2 a
High Traffic	6.7 b

*Values with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

Color ratings for MBR-18337 treated fine fescue at 19 days after antidotal applications, showed that under high traffic stress, recovery was almost non-existent (Table 24). On MBR-18337 treated plots and under low traffic, recovery was also poor. All treatments in the no-traffic regime had acceptable color ($\geq$ 7.0). However, color in the MBR-18337 treated plots was the lowest.

Table 24. Color Ratings of Fine Fescue Treated with Growth Regulators 19 Days after Antidotal Applications and the Cessation of Traffic.

Treatment	Rate kg/ha	Color Ratings — Traffic Regimes		
		None	Low	High
Mefluidide 2S	0.28	7.8 bc*	7.3 ab	6.5 a
MBR-18337 2EC	0.28	7.0 d	5.8 b	3.0 b
Flurprimidol 50W	1.68	8.5 a	8.5 a	8.0 a
Paclobutrazol 50W	1.68	7.5 c	7.6 ab	7.2 a
Flurprimidol + Mefluidide	0.84 + 0.06	8.4 ab	8.0 ab	8.0 a
Flurprimidol + MBR-18337	0.84 + 0.06	8.3 a-c	7.0 ab	6.4 a
Paclobutrazol + Mefluidide	0.84 + 0.06	8.0 a-c	8.2 a	8.2 a
Paclobutrazol + MBR-18337	0.84 + 0.06	7.9 a-c	7.8 a	7.6 a

*Values in the same column with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

Conclusions

Growth regulators in certain years may not decrease maintenance costs because of reduced turf growth in periods of high temperature and low rainfall. Traffic, if not too severe, may also enhance turfgrass appearance by wearing off senescent foliage.

Mefluidide and MBR-18337 as compared to flurprimidol, paclobutrazol alone and in combination are quicker acting materials in reducing turf growth. Paclobutrazol and paclobutrazol + mefluidide are also quick acting. Turf growth is suppressed for approximately 6.5 weeks by the materials used in this study except for MBR-18337, which suppressed growth for 8 weeks, and paclobutrazol, which suppressed growth for 10 weeks.

The materials have varying effects on turfgrass color. Severe turfgrass discoloration occurs with MBR-18337 within 5 weeks and paclobutrazol within 9 weeks after treatment. Mefluidide causes turf discoloration initially and then turf color improves. Combinations of these materials cause effects similar to those caused by mefluidide, except MBR-18337 combinations, which are injurious at 8 weeks after treatment. Flurprimidol treated grass has acceptable color and the chemical was judged suitable for regulation of a fine fescue golf course rough.

Seedhead suppression does not occur with flurprimidol and paclobutrazol. Suppression is greatest with mefluidide and MBR-18337 (> 90%), intermediate with mefluidide combinations (> 75%) and least with MBR-18337 combinations (> 60%).

GA_3 + urea is the best antidote to stimulate growth and improve color of paclobutrazol, flurprimidol and the combination treatments in

this study. Urea is equally beneficial for mefluidide-treated plots. Urea also improves the color of the other treated grass plots without completely sacrificing growth retardation. MBR-18337-treated grass cannot be successfully antidoted if subjected to traffic although color improves with urea applications.

Traffic-injured turfgrass and is particularly injurious when low traffic is applied to paclobutrazol and MBR-18337 treated plots. High traffic masks some treatment differences. GA_3 + urea promotes stress recovery of trafficked turf and will restore acceptable color within 8 days with the exception of MBR-18337-treated turf.

Site B. Late Season Applications of Flurprimidol, Paclobutrazol, and GA_3 to a Kentucky Bluegrass Lawn

Reason for Experimentation

Growth regulators would be useful in the fall to decrease mowing frequency when seasonal labora is unavailable. No studies reported to date have applied flurprimidol or paclobutrazol for turfgrass regulation in the fall season.

GA_3 (gibberellic acid) and BA (benzyladenine) have been reported to nullify or reverse retardation caused by pyrimidine-methanol compounds (Clark and Hackett, 1981). BA, or BA in combination with 2,4-D [(2,4-dichlorophenoxy)acetic acid], may decrease leaf senescence and delay chlorophyll degradation (Weaver, 1972). It was hypothesized that BA or BA + 2,4-D might decrease discoloration caused by flurprimidol or paclobutrazol without sacrificing growth retardation.

The specific objectives of this study were

1) To determine the influence of flurprimidol and paclobutrazol on the fall growth of Kentucky bluegrass.
2) To observe the effect of GA_3, BA and 2,4-D on Kentucky bluegrass previously treated with growth retardants.

Materials and Methods

A 3-year-old stand of Brunswick Kentucky bluegrass maintained at 3.5 cm was used for this study. The soil was a Hagerstown silt loam (fine, mixed, mesic Hapludalf). On 13 September 1982, the area was fertilized with a 15-6.5-12.9 (N-P-K basis) fertilizer containing soluble N at a rate of 49 kg N/ha. On 15 September, two 5.4 m^2 plots were treated as described in Chapter II in 3 replications with flurprimidol 50W at a rate of 1.68 kg/ha. Treatments were applied with a hand-held boom and irrigation was provided immediately following treatment. Plots not treated served as a non-treated check. Mowing was suspended for 5 weeks. After this time, growth regulator effects were visible. Plots were then mowed at 3.5 cm and treated in a split-block design with 2,4-D at a rate of 1.68 kg/ha. Each plot was then plit in half and one side either treated with GA_3 at a rate of 105 g/ha or BA at a rate of 0.28 kg/ha. GA_3 was applied as Gibrel Powder (5% gibberellic acid, Merk Chemical Division, Rahway, NY) and BA was applied as 6-benzyladenine (2% 6-benzyladenine, Abbott Laboratories, North Chicago, IL). Turf color was rated and canopy heights measured on 3 November, 14 December, 10 April, 1 May and 15 May. Spring green-up was visually estimated on 3 April.

Results and Discussion

Color Ratings and Canopy Height

Flurprimidol and Paclobutrazol caused slight turf discoloration in November and serious discoloration in December (Table 25). The December loss of color was the most observed in any application of flurprimidol or paclobutrazol at Penn State. The color rating was approximately 2.4 and the Kentucky blue grass apperared much like a dormant warm season turfgrass. Color of treated plots in the spring was unacceptably poor and reflected the poor spring green-up in April. Color was most objectionable in paclobutrazol treated plots. Turfgrass color then improved in treated plots but grass retained a metallic green appearance and rated lower in color throughout the spring.

Due to the excessive discoloration that occurred in this study, the author feels flurprimidol and paclobutrazol should not be applied in the fall. Apparently, growth retardants applied in the fall decrease endogenous GA_3 in turfgrass below a critical level that is necessary for normal growth and metabolism in cool temperatures and short photoperiods; therefore, dormancy results.

Canopy heights on flurprimidol and paclobutrazol treated plots were less throughout the fall and spring. In May, more retardation of growth occurred in paclobutrazol treated plots.

Response to 2,4-D, BA and GA_3

BA and 2,4-D had no effect on the color and height of flurprimidol and paclobutrazol treated grass. GA_3, however, did prevent the excessive

Table 25. Color Ratings, Spring Green-Up and Canopy Height Measurements of Kentucky Bluegrass Treated with Flurprimidol, Paclobutrazol and GA in the Fall of 1981.

Treatment	Antidote	Color Ratings					Spring Green-Up on 3 Apr.
		3 Nov.	14 Dec.	10 Apr.	1 May	15 May	%
Non-treated Check	No GA_3	8.6 a*	7.3 b	9.0 a	9.0 a	9.0 a	90 a
	GA_3	8.1 a	9.0 a	9.0 a	9.0 a	9.0 a	90 a
Flurprimidol 50W	No GA_3	6.5 b	2.5 b	4.0 b	6.0 a	7.3 a	30 b
	GA_3	8.1	8.6 a	5.6 a	4.5 b	7.0 a	45 a
Paclobutrazol 50W	No GA_3	6.6 b	2.3 b	2.8 b	4.0 a	6.0 a	10 b
	GA_3	7.8 a	8.2 a	4.0 a	4.0 a	5.0 b	30 a
		Canopy Height					
Non-treated Check	No GA_3	6.1 a	6.3 b	6.0 a	10.3 a	13.6 a	
	GA_3	6.1 a	9.8 a	6.0 a	10.5 a	14.0 a	
Flurprimidol 50W	No GA_3	4.0 a	3.9 b	2.5 b	7.3 a	8.3 a	
	GA_3	4.4 a	6.5 a	6.0 a	7.3 a	8.0 a	
Paclobutrazol 50W	No GA_3	3.6 a	3.8 b	2.5 b	6.5 a	7.5 a	
	GA_3	4.3 b	5.3 a	5.0 a	5.0 b	5.0 b	

*Values within treatment in the same column with a letter in common do not significantly differ at the 5% level of probability using the Duncan's Multiple Range Test.

discoloration seen in December in flurprimidol- and paclobutrazol-treated plots (Table 25). GA_3 treated areas had color ratings that exceeded the non-treated check. Color ratings in December for the GA_3 treated check was also higher than that on plots not treated with GA_3.

Turf color in the spring was also enhanced initially by GA_3. However, color did not improve in April and May. GA_3 treatment did not appear as beneficial in the spring.

Canopy height measurements showed GA_3 to stimulate vertical shoot growth in the fall. Treated plots in December had a height equivalent to that for the non-treated check. GA_3 stimulated shoot growth in November and December on all treated and non-treated grass plots; however, this did not continue beyond April.

Seedhead Formation

Seedhead number was increased by both flurprimidol and paclobutrazol. Culm length was reduced by paclobutrazol (Table 26).

Table 26. Effect of Fall Applications of Flurprimidol, Paclobutrazol, and GA_3 on Kentucky Bluegrass Seedhead Number and Culm Length in 1982.

	Seedheads per m^2		Culm Length
	No GA_3	GA_3	cm
Non-treated Check	1140 c*	96 a	26 a
Flurprimidol 50W	2938 b	86 a	19 ab
Paclobutrazol 50W	3595 a	344 a	9 b

*Values in the same column with a letter in common do not significantly differ at the 5% level of probability using Duncan's Multiple Range Test.

This confirms research by Chilcote et al. (1982) in Oregon where flurprimidol and paclobutrazol treatments were observed to increase the number of fertile tillers per square area. GA_3 interfered with seedhead emergence, and maintained vegetative growth in both growth retardant treated and non-treated plots. Apparently, GA_3 prevented the induction and expression of flowering when applied prior to winter.

Annual Bluegrass

Annual bluegrass that infested the plot area was injured by flurprimidol and paclobutrazol. GA_3 overcame this visible injury by restoring normal plant growth. Also, GA_3 caused annual bluegrass plants to flower in November. GA_3 might be useful for antidotal applications of annual bluegrass turf stands treated at injurious rates of pyrimidine-methanol fungicides.

Conclusions

Both flurprimidol and paclobutrazol applied in late summer cause serious discoloration of Kentucky bluegrass in December and delay spring green-up in April. Because of this effect, these materials are not suitable for grass retardation in the fall. GA_3, applied 5 weeks after the retardants,will prevent discoloration but also results in abberant spring green-up.

September applications of flurprimidol and paclobutrazol stimulate Kentucky bluegrass seedhead production in June. This is because of an increase in the number of flowering tillers. Culms of the seedheads are

shortened by paclobutrazol. Fall applied GA_3 interferes with seedhead production of Kentucky bluegrass in June.

BA and 2,4-D have no effect on turfgrass color or growth. GA_3 induces annual bluegrass to flower in the fall and restores the vigor of plants injured with either flurprimidol or paclobutrazol.