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EVALUATION OF PLANT GROWTH REGULATORS FOR USE IN GROUNDS MAINTENANCE AT MILITARY INSTALLATIONS

by

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A 3-year study to evaluate the use of plant growth regulators (PGRs) for reducing grounds maintenance costs was conducted at four military installations. Test plots were treated once a year, in the spring, for 3 consecutive years at the following installations: Red River Army Depot, Texas; Fort Leonard Wood, Missouri; Charleston Naval Weapons Station, South Carolina; and Willow Grove Naval Air Station, Pennsylvania. The objectives of this study were to: (a) evaluate the effectiveness of PGR treatments on the dominant turf species at each location; (b) determine the cost-effectiveness of PGR use versus conventional mowing practices; and, (c) provide guidance for incorporating PGRs into installation grounds maintenance programs.

Roundup + Oust and Oust + Escort were the most successful treatments evaluated over the 3-year period at the Red River Army Depot. Both treatments provided control of problem broadleaf and grass weed species without adversely affecting the desirable bermudagrass. The average duration of vegetation suppression was 10.7 weeks for Roundup + Oust and 8.7 weeks for Oust + Escort and was sufficient to reduce mowing

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to mowing alone. Cost savings ranged from 5 to 55 percent that of mowing, with Roundup + Oust being the most economical product evaluated.

Results of tests at Fort Leonard Wood showed that Embark + Escort and Embark + Telar were the most effective treatments evaluated. Both treatments provided acceptable weed control and the longest period of vegetative and seedhead suppression (9.3 weeks) of the two target grass species, Kentucky 31 tall fescue and Kentucky bluegrass. Other treatments that performed well but for shorter time periods included Event, Royal Slo-Gro + 2,4-D, and Manage + Telar. Several treatments caused temporary turf discoloration, however effects were considered tolerable for low- to medium-quality turf areas. On semi-improved grounds at Fort Leonard Wood, six treatments were cost-effective when compared to mowing alone. These treatments and respective estimates of dollars saved included: Event and Royal Slo-Gro + 2,4-D, 34 percent; Embark, Embark + Telar, and Manage + Telar, 32 percent; and Embark + Escort, 29 percent.

Oust was the most effective growth regulator tested on bahiagrass turf at the Charleston Naval Weapons Station, providing an average 10 weeks of vegetative and seedhead control throughout the study. Application of Oust caused temporary phytotoxic effects on bahiagrass; however, at no time were the discoloration effects considered objectionable. Other treatments that performed well included Event and Royal Slo-Gro. Telar and Embark + Fusilade were least effective. Estimates of cost savings were greatest with the use of Oust, which averaged a 57 percent lower per acre cost than that of mowing.

Based on data collected at the Willow Grove Naval Air Station, the most successful PGR treatments evaluated included: Embark + Escort, Telar + Manage, Royal Slo-Gro + 2,4-D, MON4625 + Banvel + 2,4-D, Escort + Manage, and Event + 2,4-D, in order of decreasing effectiveness. Embark + Escort was the most consistent treatment, providing adequate broadleaf weed control, seedhead inhibition, and 10.6 weeks of acceptable vegetation suppression. Embark + Escort and Telar + Manage were the most cost-effective treatments compared to current mowing practices. Differences in cost per acre compared to mowing were 52 and 29 percent, respectively. Escort + Manage, Royal Slo-Gro + 2,4-D, and Event + 2,4-D averaged 10 percent lower costs per acre than mowing.

General and specific recommendations for PGR use at all test sites are provided.

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Arsenal	Fusilade	MON 4625	Trooper
Bahiagrass	Grounds maintenance	Oust	X31019
Banvel	Herbicide	Plant growth regulator	2,4-D
Bermudagrass	Kentucky bluegrass	Roundup	
Embark	Kentucky 31 tall fescue	Royal Slo-Gro	
Escort	Limit	Shortstop	
Event	Manage	Telar	

Contents

Preface

This research was sponsored by the Department of the Army Engineering and Housing Support Center (EHSC) and the Department of the Navy Facilities Engineering Command (NAVFACENGCOM).

The principal investigators for this work were Ms. Linda S. Nelson and Dr. Kurt D. Getsinger, Aquatic Processes and Effects Group (APEG), Ecosystem Research and Simulation Division (ERSD), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES). The study was conducted and the report prepared by Ms. Linda S. Nelson and Drs. Kurt D. Getsinger and Kien T. Luu, APEG. Field and technical support were provided by the following personnel: Fort Leonard Wood - Messrs. Dan James, Marv Meyer, and Kim Miko; Red River Army Depot - Messrs. Tom Coleman, Gene Mann, and Bill Pasley; Charleston Naval Weapons Station - Messrs. Clifford Townsend and James Moore; Willow Grove Naval Air Station - Mr. Chuck Semet; and WES - Dr. Howard E. Westerdahl, and Mses. Cindy Teeter and Cindy Waddle. Additional assistance was provided by Mr. Don Bandel, EHSC; Ms. Lorri Schwartz, NAVFACENGCOM; Mr. Mark DeCot, US Air Force Directorate of Engineering and Services (formerly of NAVFACENGCOM); and Dr. A. J. Anderson, Natural Resources Research Program. Product manufacturers contributing technical expertise and chemical formulations for evaluation included: American Cyanamid, DuPont, Monsanto, PBI Gordon, Rhone-Poulenc, Stauffer, Uniroyal, and Valent. Technical reviews of this report were provided by Dr. Bobby L. Folsom, Jr. and Ms. Linda D. Peyman-Dove, EL, WES. The report was edited by Ms. Janean C. Shirley of the WES Information Technology Laboratory.

This investigation was performed under the supervision of Dr. John Harrison, Director, EL; Mr. Donald L. Robey, Chief, ERSD; and Dr. Thomas L. Hart, Chief, APEG.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

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1 Introduction

Vegetation maintenance at Department of Defense (DoD) military installations is a time-consuming, labor-intensive, and expensive activity. Grounds maintenance expenditures within DoD exceed an estimated $200 million annually. A large portion of this cost is delegated for mechanical mowing and/or removal of undesirable vegetation. Cost-effective alternatives to mowing are available and need to be implemented to reduce grounds maintenance expenditures.

Incorporating plant growth regulators (PGRs) into grounds maintenance operations is one method for reducing mechanical mowing and trimming. Plant growth regulators are synthetically produced compounds that when applied to a plant, will control or change some aspects of that plant's growth and development, without appreciable phytotoxic effects. Growth regulators affect a great variety of growth processes and for years have been used in many areas of plant science. For example, in agriculture, PGRs are used as yield enhancers in the production of sugar cane; and as anti-lodging agents for many cereal and forage crops to facilitate an easier and more profitable harvest. Applied to fruit crops, growth regulators promote fruit ripening, development, and thinning (Elkins 1983; Freeborg 1979). In recent years, the use of PGRs has become increasingly important for use in turfgrass management. When PGRs are applied to turfgrasses, vertical growth rate is reduced and seedhead formation may be eliminated (Bhowmik 1984; Dernoeden 1984; Duell 1989; Kaufmann 1986). Incorporating growth regulators into grounds maintenance operations has several advantages: (a) suppressed grass growth reduces mowing frequency which results in lower fuel, equipment, and labor costs; (b) reduced mowing allows reallocation of manpower for other necessary jobs; (c) reduced maintenance of steep-sloped or difficult-to-mow areas such as ammunition storage magazines and levees diminishes safety hazards; and (d) inhibition of tall, unsightly grass seedheads results in a better-looking turf.

A national survey of state roadside and maintenance programs conducted by the Transportation Research Board revealed that 21 of the 38 responding states showed some use of PGRs in their grounds maintenance programs (Transportation Research Board 1988). Those using PGRs cited cost savings through reduced mowing and manpower. Cost savings of up

to $75.00 per acre and an average reduction of two mowing cycles each year were reported.

Results of a survey identifying grounds maintenance standards and practices at Army installations showed that 21 percent of the responding installations use PGRs in their grounds maintenance programs (Peyman-Dove and Martin 1991). Of these respondents, many found growth regulators to be an effective method for reducing grounds maintenance costs. Those respondents currently not using PGRs reported the lack of guidance or information on how to incorporate them into grounds maintenance programs. Clearly, a need exists to evaluate the biological effectiveness of these products on various turfgrass species and to establish their economic value as a potential cost-saving grounds maintenance tool within the DoD.

In 1985, the Chemical Control Technology Team at the US Army Engineer Waterways Experiment Station (WES) initiated a 3-year study to evaluate the performance of selected PGRs in grounds maintenance programs at two Army and two Navy installations. The four installations participating in this study were: Fort Leonard Wood, MO; Red River Army Depot, Texarkana, TX; Charleston Naval Weapons Station, Charleston, SC; and Willow Grove Naval Air Station, Willow Grove, PA. Each site represented a different climate, vegetation type, and maintenance requirement. In addition, each installation identified a need to reduce grounds maintenance budgets and/or could identify problem mowing areas in which reduced mowing frequency would be of additional benefit. Some of these difficult-to-mow areas included: ammunition storage magazines; remote sensing security areas; ammunition production areas; runways and taxiways; and various training ranges.

The objectives of this study were to: (a) evaluate selected PGR treatments for use on turfgrass areas; (b) evaluate the cost-effectiveness of PGR use as compared to current grounds maintenance operations at each installation; and (c) provide guidance to DoD personnel on how to properly incorporate PGRs into a grounds maintenance program.

The information in this report is presented in seven parts: Chapter 1, Introduction; Chapters 2-5, reports on the 3-year field studies; Chapter 6, Cost Comparison Analysis; and Chapter 7, Recommendations. Chapters 2-5 are presented by installation and include materials and methods, results, discussion, and conclusions concerning growth regulator effects observed during each 3-year field study. Chapter 6 is written as one section for all installations and includes materials and methods, results and discussion, and conclusions based on site-specific mowing costs and PGR efficacy. The recommendations in Chapter 7 are presented as general recommendations, which are general guidelines for PGR use at all installations; and site-specific recommendations, which are recommendations for PGR use at each installation, and are based on efficacy results of the 3-year field study and the results of the cost comparison analysis.

2 Fort Leonard Wood Field Study

Materials and Methods

Plot layout and treatment

Twenty-seven test plots measuring 5.5 by 7.0 m (0.005 ha) were established on a mature stand of turf at Fort Leonard Wood, MO. Kentucky 31 tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) were the dominant grass species established in this area, comprising an estimated 75 and 20 percent of the vegetative cover, respectively. A variety of broadleaf and grassy weed species were present in small quantities (1 to 5 percent). A complete list of the major plant species identified within the test area is presented in Appendix A. The area was described as semi-improved ground and was normally mowed twice per month from April through October.

Eight different PGR treatments were selected for evaluation. Table 1 identifies products, rates, and dates of application. Treatments, rates, and treatment combinations were based on recommendations provided by respective chemical manufacturers for use on a tall fescue-bluegrass mixed turf. Some PGR treatments were tank-mixed combinations of a PGR plus a herbicide. Surfactant was added where recommended by the manufacturer. Specific information on all products evaluated is provided in Appendix B. Prior to treatment, test plots were mowed to a height of 10 cm (4 in.) and the clippings removed. Pretreatment mowing was required to provide a uniform surface for subsequent height determinations. Sprayable PGR treatments were applied using a CO_2 pressurized backpack sprayer with a four-nozzle (TeeJet 8001 VS) spray boom that delivered 280.5 L water/ha (30 gal of water per acre). A blue indicator dye, BULLSEYE^R, was added to the treatment mixture to prevent overlapping of spray patterns. Granular materials were applied by hand, ensuring even distribution over the plot area. Treatments were arranged in a completely randomized design with three replicates. Untreated control plots were included. At the conclusion of

the evaluation period, all plots were mowed and resumed their normal mowing schedule for the duration of the growing season.

1987 plot evaluation

Bluegrass and tall fescue vegetative (shoot) and seedhead heights were determined from the mean of five random measurements per plot. Vegetative and seedhead heights were taken as the length from the soil surface to the top of the foliar canopy and panicle, respectively. In addition, visual observations of turf color, percent cover of the dominant grass and weed species, bluegrass and tall fescue seedhead suppression, and surface or turf uniformity were recorded. Dates in which plots normally would require mowing (with respect to current area maintenance specifications), were recorded for each treatment and used to determine the duration of PGR effectiveness. In 1987, data were collected every 2 weeks for a maximum evaluation period of 12 weeks posttreatment. Untreated control plots were evaluated for the maximum 12-week posttreatment period, whereas PGR-treated plots were evaluated only for the time during which treatment performance was rated acceptable as defined by area maintenance specifications (i.e., mowing not essential). Installation personnel were responsible for conducting evaluations at posttreatment 2, 6, and 10 weeks. The 4-, 8-, and 12-week evaluations were conducted by the WES.

Vegetative and seedhead height data were analyzed using analysis of variance, and treatment effects were separated using the Bayes Least Significant Difference (BLSD) test at the 0.05 level. Turf color, percent coverage, turf uniformity, seedhead suppression, and duration of treatment effectiveness were not subjected to statistical analysis but were used in the evaluation of overall plot appearance.

1988 and 1989 plot evaluation

Several changes were made to improve the evaluation procedures from 1987. The changes included: performing biweekly evaluations for the full 12 weeks posttreatment on all plots; measuring an increased number of plant vegetative and seedhead heights; determining actual seedhead numbers; and rating weed control, turf quality, and color on a scale from 1 to 9. These changes were made to reduce subjectivity between the WES and installation evaluators, which reduced experimental error, and to quantify more of the observational data to allow for statistical comparison. None of the plots were to be mowed until the end of the 12-week posttreatment evaluation period.

Ten random vegetative and seedhead heights were obtained in each plot using the same procedure described for 1987. Bluegrass and tall fescue seedheads were counted by randomly tossing a ring or template (30.5 cm in diameter) three times in each plot and counting the number of seedheads delineated within the template. Partial and entire inflorescences were

counted when determining seedhead numbers. Seedhead numbers were expressed as the number of grass seedheads per square meter. Turf color was visually estimated using a 1 to 9 scale, where 1 = severe browning of the turf foliage, 5 = minimally acceptable, and 9 = optimum greenness. Weed control referred to chemical effects on broadleaf and grass weed species and was determined using a 1 to 9 scale, where 1 = no chemical effect, 5 = minimally acceptable, and 9 = excellent control, no weeds present. Overall turf quality was based upon a visual scale of 1 to 9 where, 1 = dead turf, 5 = minimally acceptable level for medium- to low-quality (semi-improved) turf, and 9 = best quality; optimum greenness, turf density and uniformity, excellent vegetative and seedhead suppression, and optimum weed control. Visual estimates of percent coverage of bluegrass, tall fescue, and weed species were recorded for each plot. A template representing 1 percent of the total plot area was used as an aid in assessing this parameter.

Seedhead counts and visual estimates of vegetative cover were recorded monthly. All other parameters were recorded biweekly. As in 1987, duration of PGR effectiveness was recorded as the date in which treated plots normally would require mowing based on area maintenance specifications.

All data collected, except the visual cover estimates and duration of PGR effectiveness, were subjected to analysis of variance. Treatment effects were separated using the BLSD test at the 0.05 level. Cover estimations were used to ascertain changes in species composition that may result from long-term PGR use. All data were collectively used to assess overall treatment performance.

Results

1987 evaluation

Kentucky 31 tall fescue. Event, Embark + Escort, Embark + Telar, and Manage + Telar were the most effective compounds used in reducing vegetative height of tall fescue (Table 2). These four treatments still showed a significant reduction in plant height versus the control at 8 weeks posttreatment, with vegetative height being 23 to 30 percent lower than untreated tall fescue. Applications of Royal Slo-Gro + 2,4-D, Shortstop + Banvel, and Embark provided acceptable growth suppression of fescue for 4 weeks posttreatment. However, these products failed to provide any further acceptable growth suppression. The product XE1019 never provided significant reduction in vegetative height of fescue compared to the control.

At 8 weeks posttreatment Event, Embark + Telar, Embark + Escort, and Manage + Telar were also the most successful products that inhibited seedhead production and/or seedhead height of tall fescue (Table 3). Event and Embark + Telar provided 100 percent seedhead inhibition through 8 weeks posttreatment, while treatments with Embark + Escort and Manage + Telar resulted in 82- and 67-percent reductions in seedhead height compared to the control, respectively.

Of the remaining products, only Shortstop + Banvel provided more than 2 weeks of significant seedhead suppression of fescue, and that occurred through 4 weeks posttreatment with a 73-percent reduction in seedhead height. As with vegetative height, XE1019 never provided any significant difference in suppression/inhibition of fescue seedheads compared to the control.

Kentucky bluegrass. Of the eight products tested, Royal Slo-Gro + 2,4-D and XE1019 were the only PGRs that showed no significant difference in the vegetative height of bluegrass compared to the control during the entire evaluation period (Table 4). All of the products, except Royal Slo-Gro + 2,4-D and XE1019, showed a significant reduction in vegetative height at the 4-week evaluation period, with height reductions ranging from 22 to 40 percent. Manage + Telar and Event provided the greatest degree of vegetative height reduction of bluegrass, with 32- and 24-percent reductions in height at 8 weeks posttreatment compared to untreated plots, respectively.

Bluegrass seedheads were significantly suppressed by Embark + Escort, Embark + Telar, Manage + Telar, and Shortstop + Banvel through the 4-week evaluation period (Table 5). However, by 8 weeks posttreatment only Event was significantly suppressing seedhead height.

Overall plot appearance. The Embark, Royal Slo-Gro + 2,4-D, Shortstop + Banvel, and XE1019 plots required mowing following the 4-week evaluation (Figure 1). Mowing was necessary in these plots due to the vegetative and seedhead heights of fescue and bluegrass, as well as weedy species such as purpletop (*Tridens flavus* (L.) Hitchc.), orchardgrass (*Dactylis glomerata*), hop clover (*Trifolium campestre* Schreb.), and plantain (*Plantago lanceolata* L.). Turf stands in the remaining four treatments, Event, Embark + Escort, Embark + Telar, and Manage + Telar, remained acceptable through the 8-week evaluation period. Mowing of these four treatments was recommended at that time due to the unacceptable vegetative height of the weedy grass, purpletop, and the seedhead height of the broadleaf weed, plantain.

Evidence of slight turf discoloration was observed at 4 through 8 weeks posttreatment in the Manage + Telar plots; however, this discoloration was considered acceptable as defined by maintenance standards for low- to medium-quality turf areas at Fort Leonard Wood. No other plots showed any distinct signs of discoloration caused by the PGR treatments.

1988 evaluation

Kentucky 31 tall fescue. At 4 weeks posttreatment, all products (with the exception of XE1019) showed a significant reduction in vegetative height of tall fescue compared to the untreated control plots (Table 6). Plots treated with Event, Manage + Telar, Embark + Telar, and Embark + Escort provided the greatest vertical growth suppression, ranging from a 38- to 41-percent reduction in vegetative height. However, by 8 weeks posttreatment Royal Slo-Gro + 2,4-D provided the best vertical growth suppression (31-percent plant height reduction versus control), followed by Manage + Telar (28-percent reduction), Event (24-percent reduction), and Embark + Telar (21-percent reduction). No other products showed a significant reduction in fescue vegetative height at this time. By 10 weeks posttreatment, there was no significant difference among any of the treatments.

Complete seedhead suppression of fescue occurred through 8 weeks posttreatment in the Event, Embark + Escort, and Royal Slo-Gro + 2,4-D plots, while the combination of Embark + Telar produced only 1.4 seedheads/m^2 and reduced seedhead height by 83 percent (Tables 7 and 8). Significant reductions in seedhead height were still being observed at 10 weeks posttreatment in the Royal Slo-Gro + 2,4-D, Embark + Telar, Event, and Embark + Escort plots, with reductions in height ranging from 51 to 78 percent. Shortstop + Banvel and XE1019 were the only two treatments that showed no significant suppression of seedhead height or number compared to the control throughout the evaluation period.

Kentucky bluegrass. Only the combination of Manage + Telar provided a significant reduction (25 percent) in vegetative height of Kentucky bluegrass compared to the control at 12 weeks posttreatment (Table 9). However, at the 8-week posttreatment evaluation period, Shortstop + Banvel, Event, Royal Slo-Gro + 2,4-D, Embark + Telar, and Manage + Telar all provided significant reductions in vegetative height, with treated bluegrass stands ranging from 21 to 32 percent shorter than untreated stands.

In the control plots, mean number of bluegrass seedheads was 132.9/m^2 at 4 weeks posttreatment (Table 7). Mean seedhead numbers were significantly reduced at this evaluation period in plots treated with Embark + Escort (5.7 seedheads/m^2, 96-percent reduction), Embark + Telar (20 seedheads/m^2, 85-percent reduction), and Manage + Telar (27.1 seedheads/m^2, 80-percent reduction). Plots treated with Embark + Escort, Embark, Manage + Telar, and Embark + Telar provided significant reduction in bluegrass seedhead height during the same period, with height being reduced from 49 to 78 percent compared to untreated controls (Table 10).

By 8 weeks posttreatment, complete suppression of bluegrass seedheads occurred in the Embark + Escort and Manage + Telar plots. Also, significant reductions in seedhead height were observed in the remaining treatments (except XE1019), with heights ranging from 28 to 80 percent less than seedhead heights measured in untreated plots. Mean seedhead

numbers were significantly less in the Embark + Telar plots (14.3 seedheads/m^2) and Embark plots (42.9 seedheads/m^2) compared to control plots (100 seedheads/m^2). There were no viable seedheads (all had matured) present by 12 weeks posttreatment in any of the plots.

Overall plot appearance. The vegetative condition of the Shortstop + Banvel, and XE1019 plots was rated as unacceptable, based on maintenance standards, at 4 weeks posttreatment, and these plots were recommended for mowing (Figure 1). This unacceptability was primarily the result of excessive fescue and bluegrass seedhead height and unevenness of the turf stand. The remaining PGR treatments provided acceptable growth retardation until 10 weeks posttreatment. By that time, the combination of tall seedheads, abundance of broadleaf and grassy weeds, and unevenness of the turf stand resulted in unacceptable ratings and recommendations for mowing.

Plant growth regulator effects on weed control are presented in Table 11. Six of the eight treatments showed minimally acceptable, and significant, weed control compared to the control plots at 12 weeks posttreatment. Plots treated with Embark + Escort and Royal Slo-Gro + 2,4-D consistently provided the best weed control at all evaluation periods. In contrast, plots treated with Embark and XE1019 provided the least acceptable weed control. Purpletop and plantain were the dominant grassy and broadleaf weeds, respectively, in most of the plots.

Slight turf discoloration was noted in some of the plots 2 weeks after treatment, particularly in the Embark + Escort and Manage + Telar plots (Table 12). This discoloration became less noticeable over time and by 12 weeks posttreatment, only one treatment (Embark + Escort) varied in color significantly from the control. The Embark + Escort treatment received the highest color rating, including the control, at the 12-week evaluation period.

The Embark + Escort treatment significantly improved the overall turf quality compared to the untreated control, as shown in Table 13. Three other treatments, Event, Embark, and Royal Slo-Gro + 2,4-D, also received higher turf quality ratings than the control at 12 weeks posttreatment, although these ratings were not statistically significant.

1989 evaluation

Kentucky 31 tall fescue. With the exception of XE1019, all products tested showed a significant reduction in vegetative height of tall fescue compared to the control at 4 weeks posttreatment (Table 14). Manage + Telar, Embark + Telar, Embark + Escort, and Event provided the greatest reduction in height, ranging from 39 to 43 percent.

Although there was no significant reduction in height compared to the control at 8 weeks posttreatment, five products (Manage + Telar, Embark + Telar, Shortstop + Banvel, Event, and Embark) showed significant reduction in vegetative height at the 10-week posttreatment evaluation period. These reductions were greatest in the Manage + Telar (25-percent reduction) and Embark + Telar (23-percent reduction) treatments. By 12 weeks posttreatment, none of the products were providing significant reductions in plant height compared to the control.

Fescue seedheads were completely suppressed through 6 weeks posttreatment in the Event, Embark + Escort, Embark + Telar, Royal Slo-Gro + 2,4-D, and Shortstop + Banvel plots. At 8 weeks posttreatment, only Embark + Escort provided complete seedhead suppression (Table 15). However, all other products, except XE1019, showed significant reductions in seedhead height compared to the control during this time (Table 16). At the 12-week evaluation period, Embark + Escort and Embark + Telar continued to provide complete seedhead suppression, while Embark + Telar, Embark, and Event provided 84- to 87-percent reduction in seedhead number.

Kentucky bluegrass. Vegetative height of Kentucky bluegrass was significantly reduced compared to the control in all treatments except those treated with Embark, Royal Slo-Gro + 2,4-D, and XE1019 at 4 weeks posttreatment (Table 17). However, at 8 weeks posttreatment, only plots treated with Manage + Telar and Shortstop + Banvel provided a significant reduction (25 percent) in bluegrass vegetative height compared to the control. No significant reductions in height were observed at the 10- and 12-week evaluation periods.

At 8 weeks posttreatment, all treatments (except Royal Slo-Gro + 2,4-D) showed a significant reduction in bluegrass seedhead height compared to the control, with Shortstop + Banvel providing the greatest reduction at 79 percent (Table 18). Yet only Shortstop + Banvel showed a significant reduction (97 percent) in the number of seedheads per square meter compared to the control during this evaluation period (Table 15). By 12 weeks posttreatment, a similar seedhead height reduction trend was noted; however, three products provided significant reductions in seedhead numbers compared to the control. These reductions were measured as 88 percent for Embark + Escort, 97 percent for Embark, and 99 percent for Shortstop + Banvel.

Overall plot appearance. Based on maintenance standards of vegetative condition, only plots treated with XE1019 were rated unacceptable and required mowing at 6 weeks posttreatment (Figure 1). An unacceptable rating resulted from excessive fescue and bluegrass seedheads and turf unevenness. Plots treated with Manage + Telar remained acceptable through 8 weeks posttreatment, while the remaining treatments provided acceptable growth retardation through 10 weeks posttreatment. These unacceptable ratings and recommendations for mowing were the result of tall seedheads, weediness, and uneven appearance of the turf stand.

Treatment effects on weed control are presented in Table 19. Five of the eight products showed minimally acceptable or better weed control compared to untreated control plots at 12 weeks posttreatment. Embark + Escort, Royal Slo-Gro + 2,4-D, and Shortstop + Banvel consistently provided the best weed control during the evaluation period. In contrast, plots treated with Embark, Event, and XE1019 provided the least acceptable weed control during the evaluation period. Purpletop, orchardgrass, hop clover, and sedges were the dominant weedy species in most of the plots.

The turf stands were slightly discolored at 2 through 6 weeks posttreatment in the Embark + Escort, Embark + Telar, and Manage + Telar plots (Table 20). However, by 8 weeks posttreatment, only Manage + Telar showed any significant discoloration from the control, and the color of this plot was still rated higher than the minimally acceptable level. There was no significant difference in color rating among treatments (including the control plots) at 10 weeks posttreatment, and by 12 weeks posttreatment, seven of the treated plots actually received higher color ratings than the control.

The treatments of Embark, Embark + Escort, and Royal Slo-Gro + 2,4-D significantly improved turf quality compared to the control at 8 weeks posttreatment (Table 21). These three treatments, as well as Embark + Telar and Shortstop + Banvel also rated higher than the control at 12 weeks posttreatment, although these ratings were not statistically significant.

Discussion

The PGRs tested at Fort Leonard Wood can be placed into four categories based on the effectiveness of the compounds over the 3-year evaluation period. This effectiveness is primarily a function of the duration of growth retardation of tall fescue and bluegrass, with respect to vegetative height, and seedhead height and number. However, other factors such as weed control, and turf color and quality, were considered when assessing effectiveness. These categories, or groups, are ranked in order of decreasing effectiveness, e.g., the first category represents the most effective products, while the fourth category represents the least effective products.

The first category includes Embark + Escort and Embark + Telar, which were the most consistent treatments tested each year. These products provided adequate broadleaf weed control and the longest periods of vegetative and seedhead suppression of the target grasses (particularly tall fescue) compared to all other products evaluated. Since Embark alone has no effect on most weedy species, the tank-mixing of this product with the herbicides Escort or Telar was implemented for weed control in the turf stand. Escort has a broader range of weed control than Telar; however, Escort can produce a higher degree of phytotoxicity on fescue and bluegrass than Telar. In fact, these effects were observed for the two tank mixes on

the Fort Leonard Wood plots. The Embark + Escort combination provided the best weed control, yet resulted in a temporary, slight discoloration (yellowing) of the turf.

The second most effective group of PGRs evaluated at Fort Leonard Wood includes Event, Royal Slo-Gro + 2,4-D, and Mange + Telar. Although Event provided good vegetative and seedhead height reduction on the target grasses (especially fescue), this product ranked low in weed control. In contrast, Royal Slo-Gro + 2,4-D provided good broadleaf weed control, and was effective in reducing the vegetative growth and seedhead production of the target grasses (particularly fescue). The effectiveness of Royal Slo-Gro on seedhead suppression of the target grasses was dramatically improved during the 1988 and 1989 growing seasons by doubling the rate of the active ingredient applied to the turf. A label modification in 1988 allowed higher rates of Royal Slo-Gro to be used on fescue and bluegrass. Duration of vegetative control was extended from 4 weeks in 1987 to 10 weeks in 1988 and 1989, when using the higher label rates of Royal Slo-Gro.

Manage + Telar provided good vegetative height reduction and seedhead suppression of bluegrass, and ranked high in vegetative height reduction of tall fescue. However, this product failed to provide long-term seedhead suppression in fescue. Since mature fescue seedheads can become tall (greater than 1 m) and unsightly, failure of a product to suppress the production or height of these seedheads can result in poor PGR effectiveness in mixed turf stands (even though the product may be effective on bluegrass). This species-specific activity emphasizes the importance of selecting the correct PGR treatment for mixed turf stands, and has been noted by other investigators (Freeborg 1983; Danneberger and Street 1986).

The products Shortstop + Banvel and Embark comprised the third most effective group of PGRs evaluated at Fort Leonard Wood. Shortstop + Banvel was not very effective on fescue (vegetative height or seedhead suppression), and was very inconsistent on bluegrass. For example, this product performed poorly on all phases of bluegrass growth retardation in 1987 (drought-stressed growing season), performed well on vegetative height reduction (but poorly on seedhead suppression) in 1988, and performed well on both vegetative height reduction and seedhead suppression in 1989. In addition, inconsistencies were noted in broadleaf weed control, within a plot and across seasons, resulting in a "spotty," uneven appearance of the turf stand. Weed control should have been enhanced with the addition of Banvel, a broadleaf herbicide. Since Shortstop + Banvel is a granular formulation, these irregular effects may be attributed to an uneven distribution of the formulation and/or lack of moisture to release the active ingredients. This problem has been reported following the use of granular formulations in other studies (Watschke 1979) and also occurred with this product at the Willow Grove field site.

When tank-mixed with a herbicide (i.e., Escort or Telar), Embark treatments performed extremely well as growth retardants on the mixed stands at Fort Leonard Wood. However, when used alone, Embark ranked low on duration of vegetation control. This low ranking of Embark (without herbicides) is directly related to the inability of the product to consistently suppress fescue seedheads and the ineffectiveness of the product to control weedy species. As noted earlier, this underscores the importance of specific activity of various PGRs, as well as the need for using PGR/herbicide combinations on mixed-turf stands. Tank mixes are economical and commonly recommended for weedy turf situations (McElroy, Rieke, and McBurney 1984; Beard 1973; Duell 1989; Freeborg 1983).

The least effective product evaluated was the experimental product XE1019. This compound consistently had little or no growth retardation/seedhead suppression effects on the target grasses, or any of the weedy species. Additional testing of XE1019, at higher rates, may help determine if the product is suitable for turf use.

The overwhelming majority of plot-mowing recommendations during the 3-year evaluation period at Fort Leonard Wood were based on one primary factor: grossly uneven appearance of the turf stand. This condition was usually a result of tall seedheads (either fescue or weeds), and the abundance of weedy species. In many cases growth retardation effects would have exceeded 12 weeks posttreatment on the target grasses (fescue/bluegrass), but weeds severely downgraded the acceptability of the treatments. Purpletop was the most problematic weed at the Fort Leonard Wood site. None of the products tested provided exceptional control of this weed, particularly after 8 to 10 weeks posttreatment. Long-term control of purpletop could greatly extend the mowing intervals at Fort Leonard Wood.

Timing of application must also be considered when using PGRs at Fort Leonard Wood. When fescue seedheads were in the "boot" stage of development, as occurred in the April 23-24 1987 treatment, only one product, Event, provided seedhead suppression at the 4-week posttreatment evaluation period. However, in 1988 and 1989, PGRs were applied earlier in the growing season and four to five of the eight products tested provided fescue seedhead suppression through 4 weeks posttreatment. It should be noted that seedhead development is dependent on local temperature and moisture conditions, which vary on a yearly basis; therefore the "window-of-application" for maximum seedhead suppression will not occur on the same calendar date each spring.

Although some of the PGRs evaluated caused temporary discoloration of the turf (most notably Embark + Escort), visual observations indicated that no turf thinning or shifts in percent cover of species occurred during the 3-year study. The highest degree of discoloration, or yellowing, of the turf was noted in 1987. However, this condition was also apparent in the untreated control plots and was probably magnified by the moderate drought which occurred in the Fort Leonard Wood area in the spring and summer of 1987. Visual observations also indicated no evidence of additional damage

from insects or disease organisms, compared to control plots, during the 3-year evaluation period.

Since PGRs impose a slight stress on the target plants, additional stresses on the turf (e.g., drought, compaction, etc.) should be considered when planning a long-term PGR treatment program. A 2- or 3-year PGR treatment period on the same turf stand, followed by a rotation to normal mowing practices, should prevent any deterioration of the turf.

Conclusions

Based on results of the 3-year PGR evaluation at Fort Leonard Wood, the following conclusions can be drawn:

a. Tank-mixed treatments of Embark + Escort and Embark + Telar provided the most consistent and acceptable growth retardation and weed control. Other treatments that performed reasonably well included Event, Royal Slo-Gro + 2,4-D, and Manage + Telar. The experimental compound, XE1019, provided no measurable growth suppression or weed control throughout the study period.

b. Treatments that did not suppress tall fescue seedheads and provide weed control were not acceptable for use at Fort Leonard Wood. The suppression of seedheads (particularly with respect to tall fescue) is more critical than sward height retardation, when maintaining an acceptable turf stand.

c. Temporary turf discoloration can be expected from PGR treatments; however, this effect is tolerable for low- to medium-quality turf areas.

d. None of the products evaluated produced permanent, detrimental effects on the turf, such as thinning or increased weed cover, as a result of 3 consecutive years of application.

e. If the optimum window of application is missed, reduced effectiveness on tall fescue and Kentucky bluegrass seedhead suppression can be expected.

3 Red River Army Depot Field Study

Materials and Methods

Plot layout and treatment

Thirty test plots measuring 5.5 m by 7.0 m (0.005 ha) were established on a mature stand of turf at Red River Army Depot (RRAD), Texarkana, TX. Bermudagrass (*Cynodon dactylon* (L.) Pers.) was the desired, managed grass species established in this area, comprising an estimated 1 percent to 55 percent of the vegetative cover. A variety of broadleaf and grassy weed species were also present. It should be noted that the percent vegetative composition varied greatly among individual plots. Turf quality was generally considered poor in the test area due the large quantity of existing weed species. A complete list of the major plant species identified within the plot area as a whole, is presented in Appendix A. The test area was described as semi-improved ground and was normally mowed approximately twice per month from April through October.

Nine different chemical treatments were selected for evaluation. Table 22 identifies products, rates, and dates of application. Treatments, rates, and treatment combinations were based on recommendations provided by respective chemical manufacturers for use on a bermudagrass turf. Surfactant was added where recommended by the manufacturer. The treatment, Arsenal, was applied while bermudagrass was dormant (pre-greenup). All other treatments were applied when bermudagrass was green (≥50 percent greenup) and actively growing. Specific information on all products evaluated is provided in Appendix B. Prior to treatment, test plots were mowed to a height of 5 cm (2 in.) and the clippings removed. Pretreatment mowing was required to provide a uniform surface for subsequent height determinations. Treatments were applied using a CO_2 pressurized backpack sprayer with a four-nozzle (TeeJet 8001 VS) spray boom that delivered 280.5 l water/ha (30 gal of water per acre). A blue indicator dye, BULLSEYE^R, was added to the treatment mixture to prevent overlapping of spray patterns. Treatments were arranged in a completely randomized

design with three replicates. Untreated control plots were included. At the conclusion of the evaluation period, all plots were mowed and resumed their normal mowing schedule for the duration of the growing season.

1987 plot evaluation

Bermudagrass vegetative (shoot) and seedhead heights were determined from the mean of 5 random measurements per plot. Vegetative and seedhead heights were taken as the length from the soil surface to the top of the foliar canopy and panicle, respectively. In addition, visual observations of turf color, percent cover of bermudagrass and weed species, bermudagrass seedhead suppression, and surface or turf uniformity were recorded. Dates in which plots normally would require mowing (with respect to current area maintenance specifications) were recorded for each treatment and used to determine the duration of treatment effectiveness. In 1987, data were collected every 2 weeks for a maximum evaluation period of 12 weeks posttreatment. Untreated control plots were evaluated for the maximum 12-week posttreatment period, whereas PGR-treated plots were evaluated only for the time during which treatment performance was rated acceptable as defined by area maintenance specifications (i.e., mowing was not essential). Installation personnel were responsible for conducting evaluations at 2, 6, and 10 weeks posttreatment. The 4-, 8-, and 12-week evaluations were conducted by the WES.

Vegetative and seedhead height data were analyzed using analysis of variance, and treatment effects were separated using the BLSD test at the 0.05 level. Turf color, percent coverage, turf uniformity, seedhead suppression, and duration of treatment effectiveness were not subjected to statistical analysis but were used in the evaluation of overall plot appearance.

1988 and 1989 plot evaluation

Several changes were made to improve the evaluation procedures from 1987. The changes included: performing biweekly evaluations for the full 12 weeks posttreatment on all plots; measuring an increased number of plant vegetative and seedhead heights; determining actual seedhead numbers; and rating weed control, turf quality, and color on a scale from 1 to 9. These changes were made to reduce subjectivity between WES and installation evaluators, which reduced experimental error, and to quantify more of the observational data to allow for statistical comparison. None of the plots were mowed until the end of the 12-week posttreatment evaluation period.

Ten random vegetative and seedhead heights were obtained in each plot using the same procedure described for 1987. Bermudagrass seedheads were counted by randomly tossing a ring or template (30.5 cm in diameter) three times in each plot and counting the number of seedheads delineated within the template. Partial and entire inflorescences were counted when

determining seedhead numbers. Seedhead numbers were expressed as the number of seedheads per square meter. Turf color was visually estimated using a 1 to 9 scale, where 1 = severe browning of the turf foliage, 5 = minimally acceptable, and 9 = optimum greenness. Weed control referred to chemical effects on broadleaf and grass weed species and was determined using a 1 to 9 scale, where 1 = no chemical effect, 5 = minimally acceptable, and 9 = excellent control, no weeds present. Overall turf quality was based upon a visual scale of 1 to 9, where 1 = dead turf, 5 = minimally acceptable level for medium- to low-quality (semi-improved) turf, and 9 = best quality; optimum greenness, turf density and uniformity, excellent vegetative and seedhead suppression, and optimum weed control. Visual estimates of percent coverage of bermudagrass and weed species were recorded for each plot. A template representing 1 percent of the total plot area was used as an aid in assessing this parameter.

Seedhead counts and visual estimates of vegetative cover were recorded monthly. All other parameters were recorded biweekly. As in 1987, duration of chemical effectiveness was recorded as the date in which treated plots normally would require mowing based on area maintenance specifications.

All data collected, except the visual cover estimations and duration of treatment effectiveness, were subjected to analysis of variance. Treatment effects were separated using the BLSD test at the 0.05 level. Cover estimations were used to ascertain changes in species composition that may result from long-term PGR use. All data were collectively used to assess overall treatment performance.

Results

1987 evaluation

None of the treatments evaluated significantly reduced bermudagrass vegetative height in 1987 (Table 23). However, effects on seedhead height and production were observed. Normal seedhead emergence started after the first plot evaluation (2 weeks posttreatment), and by 4 weeks posttreatment, only the Embark + Oust, Roundup, Roundup + Oust, Roundup + Trooper, and untreated control plots had measurable seedheads (Table 24). Seedhead heights among these treatments were not significantly different. All of the other treatments had completely inhibited seedhead emergence. The only treatment showing significantly lower seedhead heights as compared to the untreated control was Arsenal at 8 weeks posttreatment. Seedhead emergence was also suppressed for the longest period of time with this treatment.

None of the treatments evaluated exhibited phytotoxic effects (discoloration) on bermudagrass. Roundup + Oust and Oust + Escort provided the best weed control. Both of these treatments were effective on dallisgrass

(*Paspallum dilatatum*), the most troublesome weed in the test area, and also eliminated many broadleaf weed species. Arsenal and Oust also provided good weed control but for shorter periods of time (8 and 6 weeks of acceptable control, respectively).

In 1987, the duration of acceptable vegetation suppression was greatest with treatments of Roundup + Oust and Oust + Escort each providing control without mowing for 10 weeks (Figure 2). Arsenal was also fairly successful with 8 weeks of effectiveness.

1988 evaluation

Two treatments, Event and Arsenal, showed initial inhibitory effects on bermudagrass vegetative height at 2 weeks posttreatment (Table 25). Height reductions averaged 29 percent that of the untreated controls. No significant differences in foliar height were measured with any of the treatments beyond 2 weeks posttreatment.

Bermudagrass seedhead number and height were unaffected by any of the chemical treatments (Tables 26 and 27). Although not significantly different from the untreated control, seedhead number data does show complete seedhead suppression through 4 and 6 weeks posttreatment with treatments of Event and Embark + Fusilade, respectively.

Turf color was not significantly reduced as a result of chemical application (Table 28). However, at 2 weeks posttreatment, turf color for all chemically treated plots rated below minimally acceptable (<5). Visual observations recorded at this time describe thatch visibility, bare ground areas from weed kill (treatment effects), and prevailing drought conditions (very little rain since treatment; ground is dry and cracked).

Several treatments showed significant activity on weed control compared to untreated plots (Table 29). Oust + Escort, Roundup, Roundup + Oust, and Roundup + Trooper were the most effective and consistent treatments, providing acceptable (and similar) weed control throughout the evaluation period. Embark + Oust and Oust also showed acceptable (though not consistently significant) weed control. Event and Embark + Fusilade were least effective on weeds.

Turf quality assessments indicated no significant differences were evident among treatments in 1988 (Table 30). Regardless of statistical significance, several treatments did maintain above minimally acceptable turf quality (rating ≥5) through most of the study. Those treatments included: Oust + Escort, Roundup, Roundup + Oust, and Oust. Embark + Fusilade had the lowest turf quality ratings (<5) throughout the evaluation period.

Those treatments providing the longest period of acceptable vegetation control were Roundup + Oust and Arsenal (Figure 2). Vegetation was suppressed and mowing was not required for 12 weeks following application

of these products. Other successful treatments and respective duration of control included: Roundup + Trooper, 10 weeks; and Event, Oust, Oust + Escort, Roundup, all providing 8 weeks of control.

1989 evaluation

Four treatments, Embark + Oust, Oust, Oust + Escort, and Roundup + Oust, significantly reduced bermudagrass vegetative height (Table 31). Embark + Oust showed effects through 4 weeks posttreatment, whereas the other three treatments still averaged a 46-percent reduction in foliar height 6 weeks after application. Lower heights were measured through 8 weeks posttreatment, but were not significantly different.

Four weeks after chemical application, all treatments showed effects on bermudagrass seedhead number and/or seedhead height (Tables 32 and 33). Event, Embark + Fusilade, Embark + Oust, Oust, Oust + Escort, Roundup + Oust, and Roundup + Trooper completely suppressed seedhead emergence. Arsenal and Roundup were less effective, yet still reduced seedhead numbers by 87 and 66 percent, respectively. Moreover, emerged seedheads measured 72 percent shorter than those in the untreated controls. Although treatments showed initial activity on seedhead production and height, effects were short-lived as significant differences were not recorded on further evaluations.

Effects on turf color were minimal (Table 34). Oust, Oust + Escort, and Roundup + Oust were the only treatments that rated below minimally acceptable at 4 weeks posttreatment. Remarks made by the evaluator at this time described bermudagrass as green and healthy looking; however, overall plot color appeared brownish, therefore the low color rating. Arsenal and Roundup treatments also showed significantly lower color ratings than the untreated control at 4 weeks posttreatment, however, turf color for these plots was not considered unacceptable.

Several treatments demonstrated effective weed control in 1989 (Table 35). Embark + Oust, Oust, Oust + Escort, Roundup, Roundup + Oust, and Roundup + Trooper regulated weed populations for 6-8 weeks, with Roundup + Oust and Oust + Escort rated as the best overall treatments. These two treatments controlled a wider range of broadleaf weed species and were most effective on dallisgrass. Event, Arsenal, and Embark + Fusilade provided the least amount of weed control.

At 4 weeks posttreatment, Embark + Oust, Oust, Oust + Escort, Roundup, Roundup + Oust, and Roundup + Trooper showed significantly higher turf quality than the untreated control (Table 36). Roundup + Oust and Oust + Escort sustained acceptable turf quality for the longest period of time.

In 1989, Roundup + Oust was the most successful treatment for controlling vegetation at RRAD. This treatment did not require mowing for 10 weeks following application (Figure 2). Embark + Oust, Oust, Oust + Escort,

and Roundup also performed well, maintaining acceptable vegetation control for 8 weeks.

Discussion

Treatments that provided control of the problem weed grasses, mainly dallisgrass, and broadleaf weed species, usually ranked highest in terms of overall treatment performance. Tall, unsightly weeds and numerous dallisgrass seedheads disrupted turf uniformity, lowered turf quality, and shortened the duration of acceptable vegetation control. All chemical treatments tested at RRAD demonstrated some degree of broadleaf weed control; however, not all were effective on dallisgrass. Roundup + Oust and Oust + Escort were consistently the most successful treatments evaluated over the 3-year period for controlling problem weeds at RRAD. These product combinations offered more residual herbicide effects than other treatments evaluated. Event and Embark + Fusilade were the least effective on weedy species.

Once established, bermudagrass is fairly low-growing and requires little maintenance (mowing). In a semi-improved turf situation, removal of competitive weeds is a very important aspect for managing bermudagrass. The use of herbicides alone or in combination with plant growth regulating compounds on bermudagrass is often referred to as "bermuda release" or "selective weeding." Researchers and grounds managers often report measurable increases in bermudagrass cover as a result of chemical application for selective weeding (Dickens 1989; McMillan 1989; Kobelt 1989). However, visual observations of percent bermudagrass cover did not show long-term increases as a result of 3 years of chemical treatment at RRAD. Although reductions in weed populations were observed, very little bermudagrass was present on many of the plots at the time the study was initiated (1987), and a visual increase in bermudagrass cover was not observed.

"Growth regulator" effects on bermudagrass, such as reduced vegetative and seedhead height and seedhead suppression, were observed but were fairly inconsistent over the 3-year test period. Reductions in foliar height were minimal, with the greatest activity occurring in 1989 with treatments of Oust, Oust + Escort, and Roundup + Oust. Seedhead suppression was observed each year with various treatments, but effects were short-lived. Effects on seedhead production may be described more accurately as a "delay" in emergence, as seedheads were produced later that season. Although not always statistically significant, Event was the only treatment that appeared to control seedhead emergence every year. Arsenal, Embark + Fusilade, Oust, and Oust + Escort showed activity during 2 of the 3 years tested. The longest delay in seedhead emergence was noted with Arsenal in 1987 and Embark + Fusilade in 1988, both preventing seedhead emergence through 6 weeks posttreatment. Reductions in

seedhead height were recorded infrequently and were most often observed as a secondary effect once delays in seedhead emergence dissipated.

Often, large differences in seedhead numbers were evident (e.g., 1989, 8 weeks posttreatment) but treatments were not statistically significant. This suggests great variability in the data collected. A visual assessment of the plot area prior to study initiation noted large irregularities between plots. Visible differences in species composition, soil texture, and drainage existed. Selecting a suitable test area with equal experimental units was difficult at this location. As a result, large differences between replicates existed and consistently significant treatment effects were often not observed. This may also explain why no conclusive evidence of increased bermudagrass cover was observed.

Significant differences in turf color were rarely observed, suggesting bermudagrass was fairly tolerant to all the chemical treatments evaluated. The only significant color reductions were measured at 4 weeks posttreatment in 1989 with Oust, Oust + Escort, and Roundup + Oust. Effects were visible for a 2-3 week period and can be correlated with a reduction in vegetative height. Bermudagrass was described as green but stunted. As a result, overall plot color appeared brownish due to a higher visibility of underlying thatch. Drought conditions were also reported at this time. Both of these factors may have contributed to the overall low color ratings observed.

Freeborg (1983) reported that natural senescence continues at a normal rate in a growth-inhibited turf. If the grasses are under stress, the rate may accelerate, resulting in a turf that appears discolored. The degree of turf discoloration can also vary with date of application. Johnson (1990) observed that injury of "Tifway" bermudagrass to PGRs varied between years and was partially influenced by treatment date. Some chemical treatments can cause turf to exhibit a delayed spring greenup response (Dickens 1989). This may explain the low (though not statistically significant) color ratings at 2 weeks posttreatment in 1988 and 1989. Overall, the effects on turf color were temporary and could be tolerated on semi-improved turf situations.

The duration of acceptable vegetation control varied each year for all treatments. Variations in treatment efficacy can result from seasonal weather patterns (McElroy, Rieke, and McBurney 1984). Treatment effects were most persistent in 1988. Drought conditions may have attributed to these longer periods of growth suppression. Overall, Roundup + Oust was the most consistent treatment, averaging 10.7 weeks of vegetation control before requiring mowing. Other treatments and respective length of vegetation control over a 3-year period include: Oust + Escort and Arsenal, 8.7 weeks; Embark + Oust, Oust, Roundup, and Roundup + Trooper, 7-7.3 weeks; Event, 6 weeks; and Embark + Fusilade, 4.7 weeks.

Conclusions

Results of this study lead to the following conclusions:

a. Based on 3 years of small plot testing, and considering all parameters evaluated, treatments that consistently performed the best on bermudagrass turf at RRAD included: Roundup + Oust and Oust + Escort (in decreasing order of effectiveness). Arsenal also performed fairly well but did not demonstrate the broad spectrum weed control as did the other two treatments. All other treatments evaluated did not provide adequate weed control.

b. Treatments that did not control dallisgrass and broadleaf weeds were not acceptable for use at RRAD. Weed control was the most important factor determining treatment success.

c. Temporary turf discoloration can occur as a result of chemical treatment, but effects are minimal, temporary, and tolerable for semi-improved grounds.

d. Bermudagrass seedhead emergence may be delayed with chemical treatments.

e. Chemical treatments had little effect on reducing bermudagrass vegetative height.

f. The average length of vegetation suppression with all treatments evaluated was sufficient to reduce mowing on the area tested (semi-improved ground; mowed biweekly). Roundup + Oust and Oust + Escort would reduce mowing the most.

4 Charleston Naval Weapons Station Field Study

Materials and Methods

Plot layout and treatment

Twenty-one test plots measuring 5.5 m by 7.0 m (0.005 ha) were established on a mature stand of turf located in the ammunition storage area at the Charleston Naval Weapons Station (CNWS). The vegetative cover of each plot consisted of a dominant grass, bahiagrass (*Paspalum notatum*) which comprised 95-98 percent of the area (visual estimate) and a variety of broadleaf and grassy weed species (Appendix A) which were present in small quantities (2 to 5 percent). This area is described as semi-improved ground and is maintained in accordance with Navy regulation NAVSEA OP5, which states "vegetation shall be maintained to a height not to exceed 18 inches (46 cm)" (Naval Sea Systems Command 1986). The purpose of this height requirement is to minimize potential fire hazards on areas where ammunition and explosives are present. To meet this objective, mowing is normally performed at a frequency of once per month on these areas.

Six different PGR treatments were selected for evaluation. Table 37 identifies products, rates, and dates of application. Treatments, rates, and treatment combinations were based on recommendations provided by respective chemical manufacturers for use on a bahiagrass turf. Some treatments were tank-mixed combinations of a PGR plus a herbicide. Surfactant was added where recommended by the manufacturer. Specific information on all products evaluated is provided in Appendix B. Prior to treatment, test plots were mowed to a height of 15 cm (6 in.) and the clippings removed. Pretreatment mowing was required to provide a uniform surface for subsequent height determinations. Plant growth regulator treatments were applied using a CO_2 pressurized backpack sprayer with a four-nozzle (TeeJet 8001 VS) spray boom that delivered 280.5 L water/ha (30 gal of water per acre). A blue indicator dye, BULLSEYE^R, was added to the treatment mixture to prevent overlapping of spray patterns. Treatments

were arranged in a completely randomized design with three replicates. Untreated control plots were included. At the conclusion of the evaluation period, all plots were mowed and resumed their normal mowing schedule for the duration of the growing season.

1987 plot evaluation

Bahiagrass vegetative (shoot) and seedhead heights were determined from the mean of 5 random measurements per plot. Vegetative and seedhead heights were taken as the length from the soil surface to the top of the foliar canopy and panicle, respectively. In addition, visual observations of turf color, percent cover of bahiagrass and weed species, bahiagrass seedhead suppression, and surface or turf uniformity were recorded. Dates in which plots normally would require mowing (with respect to current area maintenance specifications), were recorded for each treatment and used to determine the duration of PGR effectiveness. In 1987, data were collected every 2 weeks for a maximum evaluation period of 12 weeks posttreatment. Untreated control plots were evaluated for the maximum 12-week posttreatment period; whereas PGR-treated plots were evaluated only for the time during which treatment performance was rated acceptable as defined by area maintenance specifications (i.e., mowing not essential). Installation personnel were responsible for conducting evaluations at 2, 6, and 10 weeks. The 4-, 8-, and 12-week evaluations were completed by the WES.

Vegetative and seedhead height data were analyzed using analysis of variance and treatment effects were separated using the BLSD test at the 0.05 level. Turf color, percent coverage, turf uniformity, seedhead suppression, and duration of treatment effectiveness were not subjected to statistical analysis but were used in the evaluation of overall plot appearance.

1988 and 1989 plot evaluation

Several changes were made to improve the evaluation procedures from 1987. The changes included: performing biweekly evaluations from the full 12 weeks posttreatment on all plots; measuring an increased number of plant vegetative and seedhead heights; determining actual seedhead numbers; and rating weed control, turf quality, and color on a scale from 1 to 9. These changes were made to reduce subjectivity between WES and installation evaluators, which reduced experimental error, and to quantify more of the observational data to allow for statistical comparison. None of the plots were mowed until the end of the 12-week posttreatment evaluation period.

Ten random vegetative and seedhead heights were obtained in each plot using the same procedure described for 1987. Bahiagrass seedheads were counted by randomly tossing a ring or template (30.5 cm in diameter) three times in each plot and counting the number of seedheads delineated within the template. Partial and entire inflorescences were counted when determining seedhead numbers. Seedhead numbers were expressed as the

number of grass seedheads per square meter. Turf color was visually estimated using a 1 to 9 scale, where 1 = severe browning of the turf foliage, 5 = minimally acceptable, and 9 = optimum greenness. Weed control referred to chemical effects on broadleaf and grass weed species and was determined using a 1 to 9 scale, where 1 = no chemical effect, 5 = minimally acceptable, and 9 = excellent control, no weeds present. Overall turf quality was based upon a visual scale of 1 to 9 where, 1 = dead turf, 5 = minimally acceptable level for medium- to low-quality (semi-improved) turf, and 9 = best quality; optimum greenness, turf density and uniformity, excellent vegetative and seedhead suppression, and optimum weed control. Visual estimates of percent coverage of bahiagrass and weed species were recorded for each plot. A template representing 1 percent of the total plot area was used as an aid in assessing this parameter.

Seedhead counts and visual estimates of vegetative cover were recorded monthly. All other parameters were recorded biweekly. As in 1987, duration of PGR effectiveness was recorded as the date in which treated plots normally would require mowing based on area maintenance specifications.

All data collected, except the visual cover estimates and duration of PGR effectiveness, were subjected to analysis of variance. Treatment effects were separated using the BLSD test at the 0.05 level. Cover estimations were used to ascertain changes in species composition that may result from long-term PGR use. All data were collectively used to assess overall treatment performance.

Results

1987 evaluation

In 1987, four PGR treatments were effective at reducing vegetative (foliar) height of bahiagrass (Table 38). These treatments included: Oust, Embark + Oust, Event, and Telar. The longest period of vegetative height suppression was measured on Oust-treated plots. Oust was effective through 8 weeks posttreatment, significantly reducing vegetative height by 39, 40, and 27 percent at 4, 6, and 8 weeks after application, respectively. Embark + Oust, Event, and Telar were also effective, reducing bahiagrass height by 43, 36, and 32 percent at 4 weeks posttreatment.

Production of bahiagrass seedheads on untreated test areas began in late May, approximately 5 weeks after the PGR treatments were applied. Seedhead measurements showed that all PGR treatments were effective, to some degree, in reducing seedhead height (Table 39). In addition, several treatments were effective at delaying seedhead production. At 6 weeks posttreatment, plots sprayed with Event, Embark + Oust, and Oust showed complete suppression of seedhead production. By 8 weeks posttreatment, the Event plots showed a slight break in activity with 5 percent seedhead

emergence; however, plots treated with Embark + Oust and Oust were still completely void of seedheads. Delayed seedhead production continued through 10 weeks posttreatment, with less than 5 percent seedhead emergence occurring in the Oust plots and 10 percent seedhead emergence occurring in the Embark + Oust plots. The average heights of those seedheads that did emerge at this time were 22 and 17 percent shorter for Embark + Oust and Oust, respectively, as compared to the untreated control. Event was also an effective seedhead height inhibitor, reducing the length of seedhead stalks by 29 percent at 8 weeks posttreatment.

Visual differences in turf color were also observed following PGR treatment. Two weeks after chemical application, all treatments except Royal Slo-Gro showed evidence of turf discoloration or phytotoxicity. This condition was described as a slight chlorosis of bahiagrass foliage and in some instances (with Embark + Oust and Oust treatments), leaf-tip purpling on young leaves occurred. By the next evaluation period, these effects had dissipated and overall turf color of plots treated with Event and Oust now appeared brownish. At no time were the discoloration effects considered objectionable as defined by maintenance standards for low- to medium-quality turf areas at this installation.

None of the chemical treatments tested were effective in reducing or suppressing broadleaf or grass weed populations. Weed species that were most troublesome, thereby producing an overall uneven appearance included: Eastern gamagrass (*Tripsacum dactyloides* L.); vasey grass (*Paspalum urvillei*); and milkweed (*Asclepias* spp.). Other weed species present were infrequent, low-growing plant types and did not interfere with the overall vegetative appearance.

The most successful treatments for controlling vegetation at an acceptable level (within the 18-in. (46-cm) height requirement) thereby reducing mowing frequency, included: Oust, Embark + Oust, and Event (Figure 3).

1988 evaluation

Four weeks after chemical application, all PGR treatments significantly suppressed bahiagrass vegetative growth compared to the untreated control (Table 40). The most effective of these treatments included Event, Embark + Fusilade, Embark + Oust, and Oust; all reducing canopy height by an average 33 percent. Very little growth occurred from the 4- to the 6-week evaluation period, and by 8 weeks posttreatment, only Oust and Royal Slo-Gro exhibited significantly reduced vegetative heights. As in 1987, some PGR treatments were effective in reducing seedhead height as well as suppressing seedhead production (Tables 41 and 42). Two weeks following chemical application, four treatments (Event, Embark + Fusilade, Embark + Oust, and Oust) were successful in completely inhibiting seedhead emergence. Seedheads were present on Telar and Royal Slo-Gro treated plots; however, their height was significantly reduced by 44 and 20 percent, respectively.

Four weeks after chemical application, seedhead numbers indicated a greater than 95 percent reduction of bahiagrass seedheads with treatments of Event, Embark + Fusilade, and Oust. Seedheads were not measured for these treatments at this time, as a random sample could not be obtained. Both seedhead height and number were significantly reduced with treatments of Embark + Oust, Telar, and Royal Slo-Gro.

Seedhead height measurements recorded at 6 weeks posttreatment indicated that only three PGR treatments showed significantly lower heights. Royal Slo-Gro was the most effective, reducing stalk height by 55 percent, followed by Oust, 41 percent; and Event, 35 percent.

Seedhead numbers at 8 weeks posttreatment revealed continued significant suppression with Royal Slo-Gro, Oust, and Embark + Fusilade. In addition, these treatments showed a significant reduction in seedhead height. Royal Slo-Gro suppressed seedhead number by 98 percent and seedhead height by 41 percent. Oust and Embark + Fusilade suppressed seedhead production by 92 and 84 percent, and seedhead height by 39 and 25 percent, respectively. Although lower seedhead numbers were measured with Event, Embark + Oust, and Telar, results were not significant. Event and Embark + Oust were, however, effective in producing significantly shorter seedheads compared to the untreated control.

By 10 weeks posttreatment, only Oust and Royal Slo-Gro showed significant activity on seedhead height. Reductions in seedhead numbers were still evident (as high as 68 percent) with all treatments by the final evaluation (12 weeks); however, results were not significant. Moreover, no significant differences in seedhead height were observed at this time.

Differences in turf color are reported in Table 43. Two weeks after chemical application, only turf treated with Embark + Fusilade exhibited significantly reduced color effects. Bahiagrass was rated "minimally acceptable" and was described as chlorotic with moderate, red-purple leaf tip discoloration. These effects were still visible but to a lesser degree at 4 weeks posttreatment, and dissipated by the next evaluation period. Some bahiagrass leaf tip discoloration was reported for all PGR treatments four weeks after application; however, overall turf color was still rated minimally acceptable or better.

Two weeks after application, weed control ratings for all PGR treatments indicated some degree of effectiveness (Table 44). Broadleaf and grass weed species showed initial signs of stunting and chlorosis. However, this activity was temporary and weed species recovered. Even though results indicated some significant differences as compared to the untreated control, overall effects on weed control were rated unacceptable.

Turf quality varied greatly for each PGR treatment (Table 45). No significant differences were observed at 2 weeks posttreatment, but by the 4-week evaluation, all treatments except Telar showed significantly higher turf quality ratings when compared to the untreated (and unmowed) control.

Oust and Royal Slo-Gro had the highest ratings over the longest period of time, providing acceptable turf quality through 10 weeks. None of the treatments resulted in significantly lower quality ratings as compared to an untreated, unmowed control. In general, treatments with poor seedhead suppression and unacceptable weed control were those with low and unacceptable turf quality ratings.

In 1988, the duration of acceptable plant growth regulating activity was greatest with treatments of Oust and Royal Slo-Gro, each providing vegetation control for 12 weeks (Figure 3). Event was also fairly successful with 10 weeks of effectiveness. Embark + Fusilade, Embark + Oust, and Telar were the least effective treatments.

1989 evaluation

All treatments except Embark + Fusilade were significantly effective in reducing vegetative height of bahiagrass (Table 46). Two weeks after application, plant height was reduced by 43 percent with treatments of Oust and Telar. Event, Embark + Oust, and Royal Slo-Gro, also exhibited growth inhibition, with decreases in foliar height of 34, 27, and 27 percent, respectively. Effects continued through 4 weeks with these treatments; however, by the 6-week evaluation, only Oust remained effective. No significant differences were measured 8 weeks following treatment. Test plots were inadvertently destroyed by mowers following the 8-week evaluation; therefore no data were collected after this time.

Several PGR treatments were effective inhibitors of seedhead height and number (Tables 47-48). Seedhead emergence was just beginning at the time of the 4-week evaluation; therefore, no significant differences in seedhead number were observed at that time. Only one PGR treatment, Embark + Fusilade, had a sufficient number of seedheads present for measuring a random height sample. Measurements of this treatment indicated a significant (11-percent) reduction in seedhead height as compared to the untreated control. Significant differences in height were not observed at 6 weeks posttreatment, but on the final evaluation, both Oust and Telar showed reductions in seedhead height by 24 and 19 percent, respectively. Oust, Telar, Event, and Royal Slo-Gro all showed significant seedhead suppression activity 8 weeks after application. The most effective of these treatments was Oust, suppressing seedhead production by 87 percent as compared to the control, followed by Event (63 percent), Telar (58 percent), and Royal Slo-Gro (56 percent). Embark + Fusilade and Embark + Oust had no significant effect on seedhead production.

Event, Embark + Oust, Royal Slo-Gro, Telar, and Oust all produced discoloration effects on bahiagrass, with Oust exhibiting the most pronounced effect (Table 49). For all treatments, effects were evident at 2 and 4 weeks posttreatment, but dissipated shortly thereafter. Discoloration was described as a slight chlorosis with slight to moderate red leaf-tips.

Overall, despite significant differences, turf color rated above the minimally acceptable level for all PGR treatments throughout the experiment.

Initial chlorotic appearance of weed species indicated some chemical effect; therefore, acceptable weed control ratings were recorded at 2 weeks posttreatment (Table 50). These effects, however, were temporary and weed species recovered. Overall, regardless of significant differences as compared to the untreated control (at 4 and 6 weeks), all PGR treatments provided less than acceptable weed control. The most problematic weeds identified were Eastern gamagrass, vasey grass, and milkweed.

In 1989, none of the PGR treatments significantly affected turf quality when compared to an untreated control (Table 51). Turf quality ranked below the minimally acceptable level at 6 weeks posttreatment for all treatments, including the control, indicating maintenance standards were not being met and subsequent mowing was required. Visual observations at 12 weeks posttreatment indicated no negative impacts, such as turf thinning or undesirable changes in species composition, were evident as a result of PGR use.

Chemical effectiveness was not as persistent for some treatments as in previous years. Duration of control for all PGR treatments in 1989 was 6 weeks (Figure 3).

Discussion

Seedhead suppression was the most important factor determining success of a PGR treatment at CNWS. Bahiagrass produces an excessive number of tall, rapidly growing seedheads which disrupt turf uniformity. Once seedheads began forming on test plots, turf quality ratings fell below the minimally acceptable level. Even though some PGR treatments were effective in significantly reducing vegetative height as compared to the untreated control, bahiagrass heights for all treated and untreated plots never exceeded the maximum allowed height requirement of 18 in. (46 cm) until 10 weeks posttreatment. Therefore, the ability of a PGR to suppress foliar height of bahiagrass was not as critical as controlling seedhead production.

Oust was the most consistent growth regulator tested, providing the longest periods of vegetative and seedhead control each year. Although Oust produced the most phytotoxic effects, at no time were these discoloration effects considered objectionable for low- to medium-quality turf. Both Event and Royal Slo-Gro provided adequate control, but for shorter periods of time than Oust. In the case of Royal Slo-Gro, new manufacturer label rates imposed in 1988 (label rates were doubled) resulted in greater efficacy with this treatment in the second year of experimentation. Treatments that were least effective throughout this study included Embark + Fusilade and Telar. Neither provided adequate bahiagrass seedhead suppression.

Other investigators have reported similar results on bahiagrass with Oust, Maleic hydrazide (the active ingredient in Royal Slo-Gro), and Event (ACP1911). DiPaola and Lewis (1987 and 1989) and Lewis and DiPaola (1987) reported excellent seedhead suppression (>90 percent) with these products on bahiagrass turf trials in North Carolina. The researchers also observed initial reductions in turf quality due to leaf discoloration; however, overall quality was considered acceptable for low maintenance turf settings.

None of the treatments tested at CNWS were effective in reducing broadleaf or grass weed populations. The most troublesome weed species were tall-growing species that disrupted turf appearance and uniformity. Many PGRs used for turfgrass management are both species-specific for particular grasses and are not effective on dicotyledonous weeds common to turf areas (Freeborg 1983; McElroy, Rieke, and McBurney 1984; Duell 1989). Unsuppressed weeds not only gain a competitive advantage against the growth-regulated turfgrass, but also result in an unsightly, uneven-appearing turf. Therefore, to maintain aesthetics, a common practice has been to tank mix appropriate herbicides with the growth regulator (Freeborg, 1979 and 1983). In addition, Duell (1989) indicated that one application of a PGR-herbicide tank mix would have economic advantages as well. Effective weed suppression may have lengthened the period of control for many of the PGR treatments evaluated.

After 3 years of chemical application to the same turf area, no visible effects of continuous PGR use, such as turf thinning and increased weed populations, were evident with any of the treatments evaluated. Discoloration effects were apparent each year; however, these effects were temporary and did not result in permanent turf damage. Careful examination revealed that this "browning" effect was not due to chemical phytotoxicity but rather to the brown, underlying thatch that was more visible through the stunted bahiagrass foliage. Temporary turf discoloration is commonly associated with, but not always a direct result of, PGR applications alone (Duell 1989; Kaufmann 1985).

Differences in the duration of control from year to year can be explained by weather patterns and perhaps timing of application. Kaufmann (1980) observed that the duration of PGR effects varies greatly with the prevailing climatic conditions and by the dates of application. In 1987, a drought period occurred following PGR treatment, which may explain the longer periods of growth control observed that year. Observations made in 1987 indicated that normal bahiagrass seedhead production generally began in late May at this location. Since suppression of bahiagrass seedheads was an important factor in determining overall PGR performance, an attempt was made to maximize the length of seedhead suppression by timing the chemical application to coincide with seedhead production. In 1988 and 1989, treatment dates were timed to correspond with the period just prior to seedhead emergence. This was an effective method in 1988. In 1989, seedheads had already formed, although they had not completely emerged at the time of application. This factor, combined with an unsatisfactory pretreatment mowing (uneven

cut), which normally would eliminate early seedhead breakthrough, resulted in poor PGR performance. None of the PGR treatments provided control for longer than 6 weeks in 1989. These results demonstrated that careful site preparation and proper timing of application are important factors for obtaining successful growth regulator performance.

Conclusions

Results of this study lead to the following conclusions:

a. Of the chemical treatments evaluated, Oust performed the best. Oust was the most consistent treatment, providing the longest periods of vegetation and seedhead control each year. Other treatments that performed well included Event and Royal Slo-Gro. Telar and Embark + Fusilade were least effective.

b. Treatments that did not suppress bahiagrass seedhead production were not acceptable for use at CNWS.

c. Temporary turf discoloration can be expected from chemical treatments; however, this effect is tolerable for low- to medium-quality turf areas.

d. None of the treatments evaluated were effective growth inhibitors of the following weed species: Eastern gamagrass (*Tripsacum dactyloides* L.), milkweed (*Asclepias* spp.), and vasey grass (*Paspalum urvillei*).

e. None of the treatments evaluated produced permanent, detrimental effects, such as turf thinning or increased weed populations, as a result of 3 years of application to the same stand of turf.

5 Willow Grove Naval Air Station Field Study

Materials and Methods

Plot layout and treatment

Twenty-seven test plots measuring 5.5 m by 7.0 m (0.005 ha) were established on a mature stand of turf adjacent to the airport runway area at the Willow Grove Naval Air Station (WGNAS). Kentucky 31 tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) were the dominant grass species established in this area, comprising an estimated 60 and 30 percent of the vegetative cover, respectively. A variety of broadleaf and grassy weed species were present in small quantities (1-5 percent). A complete list of the major plant species identified within the plot area is presented in Appendix A. The area was described as semi-improved ground and was normally mowed twice per month from April-June and monthly thereafter for the remainder of the growing season (end of October). Frequent mowing was required during the spring months when rapid vertical growth in addition to grass seedhead production occurred.

Eight different PGR treatments were selected for evaluation. Table 52 identifies products, rates, and dates of application. Treatments, rates, and treatment combinations were based on recommendations provided by respective chemical manufacturers for use on a tall fescue-bluegrass mixed turf. Some treatments were tank-mixed combinations of a PGR plus a herbicide. Surfactant was added where recommended by the manufacturer. Specific information on all products evaluated is provided in Appendix B. Prior to treatment, test plots were mowed to a height of 11 cm (4.5 in.) and the clippings removed. Pretreatment mowing was required to provide a uniform surface for subsequent height determinations. Sprayable PGR treatments were applied using a CO_2 pressurized backpack sprayer with a four-nozzle (TeeJet 8001 VS) spray boom that delivered 280.5 L water/ha (30 gal of water per acre). A blue indicator dye, BULLSEYE^R, was added to the treatment mixture to prevent overlapping of spray patterns. Granular materials were applied by hand, ensuring even distribution over the plot area.

Treatments were arranged in a completely randomized design with three replicates. Untreated control plots were included. Plots were not mowed following PGR application until after the 12-week posttreatment evaluation period. At the conclusion of the evaluation period, all plots were mowed and resumed their normal mowing schedule for the duration of the growing season.

1987 plot evaluation

Bluegrass and tall fescue vegetative (shoot) and seedhead heights were determined from the mean of 5 random measurements per plot. Vegetative and seedhead heights were taken as the length from the soil surface to the top of the foliar canopy and panicle, respectively. In addition, visual observations of turf color, percent cover of the dominant grass and weed species, bluegrass and tall fescue seedhead suppression, and surface or turf uniformity were recorded. Dates in which plots normally would require mowing (with respect to current area maintenance specifications), were recorded for each treatment and used to determine the duration of PGR effectiveness. In 1987, data were collected every 2 weeks for a maximum evaluation period of 12 weeks posttreatment. Untreated control plots were evaluated for the maximum 12-week posttreatment period; whereas PGR-treated plots were evaluated only for the time during which treatment performance was rated acceptable as defined by area maintenance specifications (i.e., mowing not essential). Installation personnel were responsible for conducting evaluations at posttreatment 2, 6, and 10 weeks. The 4-, 8-, and 12-week evaluations were conducted by the WES.

Vegetative and seedhead height data were analyzed using analysis of variance, and treatment effects were separated using the BLSD test at the 0.05 level. Turf color, percent coverage, turf uniformity, seedhead suppression, and duration of PGR treatment effectiveness were not subjected to statistical analysis but were used in the evaluation of overall plot appearance.

1988 and 1989 plot evaluation

Several changes were made to improve the evaluation procedures from 1987. The changes included: performing biweekly evaluations for the full 12 weeks posttreatment on all plots; measuring an increased number of plant vegetative and seedhead heights; determining actual seedhead numbers; and rating weed control, turf quality, and color on a scale from 1 to 9. These changes were made to reduce subjectivity between WES and installation evaluators, which reduced experimental error, and to quantify more of the observational data to allow for statistical comparison. None of the plots were mowed until the end of the 12-week posttreatment evaluation period.

Ten random vegetative and seedhead heights were obtained in each plot using the same procedure described for 1987. Bluegrass and tall fescue seedheads were counted by randomly tossing a ring or template (30.5 cm in diameter) three times in each plot and counting the number of seedheads delineated within the template. Partial and entire inflorescences were counted when determining seedhead numbers. Seedhead numbers were expressed as the number of grass seedheads per square meter. Turf color was visually estimated using a 1 to 9 scale, where 1 = severe browning of the turf foliage, 5 = minimally acceptable, and 9 = optimum greenness. Weed control referred to chemical effects on broadleaf and grass weed species and was determined using a 1 to 9 scale, where 1 = no chemical effect, 5 = minimally acceptable, and 9 = excellent control, no weeds present. Overall turf quality was based upon a visual scale of 1 to 9, where 1 = dead turf, 5 = minimally acceptable level for medium- to low-quality (semi-improved) turf, and 9 = best quality; optimum greenness, turf density and uniformity, excellent vegetative and seedhead suppression, and optimum weed control. Visual estimates of percent coverage of bluegrass, tall fescue, and weed species were recorded for each plot. A template representing 1 percent of the total plot area was used as an aid in assessing this parameter.

Seedhead counts and visual estimates of vegetative cover were recorded monthly. All other parameters were recorded biweekly. As in 1987, duration of PGR effectiveness was recorded as the date in which treated plots normally would require mowing based on area maintenance specifications.

All data collected, except the visual cover estimates and duration of PGR effectiveness, were subjected to analysis of variance. Treatment effects were separated using the BLSD test at the 0.05 level. Cover estimations were used to ascertain changes in species composition that may result from long-term PGR use. All data were collectively used to assess overall treatment performance.

Results

1987 evaluation

Kentucky 31 tall fescue. Four weeks after chemical application, five treatments significantly reduced tall fescue vegetative growth compared to the untreated control (Table 53). Embark + Escort, Escort + Manage, and Telar + Manage were most effective, reducing canopy height by an average of 44 percent compared to the untreated control. Similar effects were observed 6 weeks after application, and by 8 weeks posttreatment, height reductions averaging 36 percent were still evident on plots treated with Embark + Escort, Telar + Manage, and MON4625 + 2,4-D + Banvel. Data were not collected at the 2-week evaluation interval, and by the final survey, no significant differences in plant height were evident.

Growth regulator effects on tall fescue seedhead height and seedhead production were also observed with several treatments. Visual estimations of seedhead numbers at 4 weeks posttreatment showed that Embark + Escort and Escort + Manage worked best on tall fescue. Less than 5 percent of fescue seedheads emerged in these test areas throughout the evaluation period. The overall height of those few seedheads that did emerge was also severely inhibited, measuring >85 percent shorter compared to the untreated control (Table 54). Telar + Manage and MON4625 + 2,4-D + Banvel were also effective seedhead suppressants, with only 10 and 25 percent seedhead emergence occurring, respectively. Again, seedhead heights of those that did emerge were reduced. All other treatments were unsuccessful seedhead inhibitors of tall fescue.

Limit + 2,4-D + Banvel, Royal Slo-Gro + 2,4-D, and Shortstop + Banvel were not effective treatments on tall fescue. Seedhead production, as well as vegetative height, were not adequately controlled to meet ar·a maintenance standards using these products.

Kentucky bluegrass. Four treatments were effective inhibitors of Kentucky bluegrass through 8 weeks posttreatment (Table 55). Reductions in vegetative height were measured at 4 weeks posttreatment and were still evident 8 weeks following treatment. Compared to the untreated control, these treatments and their averaged percent growth reductions over an 8-week period included: MON4625 + 2,4-D + Banvel, 41 percent; Telar + Manage, 36 percent; Embark + Escort, 34 percent; and Escort + Manage, 34 percent. Event + 2,4-D showed initial activity on bluegrass at 4 weeks posttreatment; however, subsequent measurements were not recorded as plots required mowing.

None of the treatments inhibited bluegrass seedhead emergence, yet seedhead heights were greatly reduced (Table 56). Consistent with results on vegetative height, Embark + Escort, MON4625 + 2,4-D + Banvel, and Escort + Manage were most effective, significantly reducing seedhead height by an average of 52 percent at 8 weeks posttreatment.

Overall plot appearance. Embark + Escort was the only treatment that noticeably affected turf color. A slight chlorosis, which appeared more severe on tall fescue than on Kentucky bluegrass, was evident 4 weeks following application. Effects were temporary, dissipating by 8 weeks posttreatment, and were not considered objectionable for medium-quality or semi-improved turf areas.

Embark + Escort, Escort + Manage, Telar + Manage, MON4625 + 2,4-D + Banvel, and Limit + 2,4-D + Banvel provided the best broadleaf weed control. All other treatments provided some control; however, overall effectiveness was not adequate. The only weed species that was not affected by any of the treatments was orchardgrass (*Dactylis glomerata*). Those treatments providing the longest period of acceptable vegetation control, as defined for semi-improved grounds at WGNAS, were Embark + Escort and MON4625 + 2,4-D + Banvel (Figure 4). Each of these treatments

controlled vegetation and therefore did not require mowing for 12 weeks. Escort + Manage and Telar + Manage provided adequate control for an 8-week period. All other treatments did not sustain growth regulating activity long enough to significantly reduce mowing frequency.

1988 evaluation

Kentucky 31 tall fescue. Statistically significant differences in tall fescue vegetative height were measured throughout the 12-week evaluation period, with the greatest height reductions occurring at 4 and 6 weeks posttreatment (Table 57). Embark + Escort and Telar + Manage showed the best results at 4 weeks posttreatment, reducing foliar height by 59 and 52 percent, respectively. By the 6-week evaluation period, plant heights for all treatments averaged 42 percent lower than the untreated control and showed no significant differences among treatments. By the final evaluation, differences between treatment means again showed that Embark + Escort and Telar + Manage proved to be the most effective.

All chemical treatments tested showed reductions in seedhead number and/or seedhead height at some time during the 1988 experiment (Tables 58 and 59). At 4 weeks posttreatment, six treatments completely inhibited tall fescue seedhead emergence. Some breakthrough did occur at 8 weeks posttreatment; however, Embark + Escort, Limit + 2,4-D + Banvel, MON4625 + 2,4-D + Banvel, and Royal Slo-Gro + 2,4-D still showed an average of 90 percent fewer seedheads than the untreated control. Seedhead heights were also significantly shorter than untreated plots at this time, with Embark + Escort ranking the most effective. Escort + Manage was initially effective with an 82-percent reduction in seedhead number at 4 weeks posttreatment; however, as with Telar + Manage, chemical effectiveness greatly decreased with time. Shortstop + Banvel was the least effective inhibitor of tall fescue seedhead height and production.

Kentucky bluegrass. Bluegrass vegetative growth was significantly reduced through 8 weeks posttreatment by all chemical treatments evaluated (Table 60). Effects were greatest 6 weeks following application, with canopy heights averaging 59 percent lower than the untreated control. Embark + Escort, Limit + 2,4-D + Banvel, MON4625 + 2,4-D + Banvel, and Telar + Manage exhibited the longest periods of growth control, with significant height reductions still evident 12 weeks after treatment.

Several PGR treatments were effective in reducing seedhead height as well as suppressing seedhead production (Tables 61 and 58). Reductions in seedhead number were greatest with treatments of Embark + Escort, Escort + Manage, MON4625 + 2,4-D, Banvel, and Shortstop + Banvel. Although not statistically different than the aforementioned treatments, some seedhead breakthrough was measured with Escort + Manage. Seedhead height measurements showed that this treatment also significantly reduced seedhead height by 53 percent as compared to the untreated control. Treatments that did not suppress seedhead production but were effective seedhead

height inhibitors included: Event + 2,4-D, Limit + 2,4-D + Banvel, and Telar + Manage. Royal Slo-Gro + 2,4-D had no effect on bluegrass seedhead production or height. Seedheads matured shortly after the 4-week post-treatment evaluation on all plots; therefore, subsequent measurements on height and number could not be accurately assessed.

Overall plot appearance. Initial turf discoloration was noted 2 weeks following chemical application with 5 of the 8 treatments tested (Table 62). By 4 weeks posttreatment, all treatments showed significantly lower color ratings than the untreated control; however, only three treatments, Embark + Escort, Telar + Manage, and Escort + Manage, ranked minimally acceptable or lower. Discoloration was described as a moderate chlorosis and burn on leaf tips of tall fescue. No color injury was apparent on bluegrass. Effects were temporary, dissipating by the next evaluation period. On the final evaluation, the color of all plots, including the untreated controls, was considered poor and dropped below the acceptable rating. At this time, bluegrass appeared dormant (brown and dry) and tall fescue showed signs of severe leaf curling or rolling. These effects were not considered a result of chemical toxicity, but rather as a result of drought-induced water stress.

Effective weed control was observed with several treatments (Table 63). It should be noted, however, that significant differences between the treated plots and the untreated control did not necessarily correlate with an acceptable level (rating ≥5) of weed control. Treatments giving the best overall control of broadleaf weeds included: Embark + Escort, Limit + 2,4-D + Banvel, and MON4625 + 2,4-D + Banvel. Shortstop + Banvel, Royal Slo-Gro + 2,4-D, and Telar + Manage were least effective.

No significant differences in turf quality were observed at 2 weeks post-treatment, but by the 4-week evaluation, all treatments showed significantly higher turf quality ratings when compared to the untreated control (Table 64). Embark + Escort, Limit + 2,4-D + Banvel, and MON4625 + 2,4-D + Banvel had the highest ratings over the longest period of time. Satisfactory seedhead suppression and weed control contributed to high turf quality ratings with these treatments. None of the treatments exhibited effects that resulted in significantly lower turf quality ratings than the untreated control, indicating no permanent, detrimental treatment phytotoxicity.

In 1988, the duration of acceptable PGR activity was greatest with treatments of Embark + Escort and Limit + 2,4-D + Banvel, each providing vegetation control for 12 weeks (Figure 4). Event + 2,4-D, MON4625 + 2,4-D + Banvel, Royal Slo-Gro + 2,4-D, and Telar + Manage were also fairly successful, with 8 weeks of effectiveness. Escort + Manage and Shortstop + Banvel were the least effective treatments.

1989 evaluation

Test plots were inadvertently mowed following the 8-week posttreatment evaluation in 1989. Consequently, tables reflect data collection through this time period only.

Kentucky 31 tall fescue. Three treatments, Embark + Escort, Escort + Manage, and Telar + Manage, were most effective at reducing the vegetative height of tall fescue (Table 65). Effects were evident 4 weeks after application and measured as much as 47 percent (Embark + Escort) lower than the untreated control. Significant height reductions persisted through 8 weeks posttreatment with these products. Event + 2,4-D and Royal Slo-Gro + 2,4-D showed initial growth inhibition at 2 weeks posttreatment; however, effects dissipated prior to the next evaluation.

Several treatments were effective inhibitors of tall fescue seedhead height and number (Tables 66 and 67). Embark + Escort and Escort + Manage showed the best inhibitory effects on seedhead number. Eight weeks after chemical application, these treatments still inhibited seedhead production by 83 and 61 percent, respectively, as compared to the untreated control. A delay in seedhead emergence was observed on plots treated with Event + 2,4-D, Royal Slo-Gro + 2,4-D, and Telar + Manage. Seedheads did not emerge until after the 4-week evaluation with these treatments. Limit + 2,4-D + Banvel, MON4625 + 2,4-D + Banvel, and Shortstop + Banvel showed initial increases in seedhead number at 4 weeks posttreatment; however, further differences from the untreated control were not observed. Seedhead height measurements recorded at 4 and 8 weeks posttreatment revealed that all treatments were successful at reducing inflorescence height as they emerged. The greatest reduction in seedhead height measured 37 percent that of the untreated control.

Kentucky bluegrass. Growth regulator activity was less prevalent on Kentucky bluegrass than tall fescue. Only three treatments, Embark + Escort, Escort + Manage, and Telar + Manage, significantly reduced bluegrass vegetative height (Table 68). Canopy heights measured an average 33 percent lower than the untreated control at 4 weeks posttreatment. Effects were short-lived, dissipating by the following evaluation period.

None of the treatments influenced bluegrass seedhead production; however, all treatments reduced seedhead height (Tables 67 and 69). Height reductions as large as 50 percent (Embark + Escort) were recorded at 4 weeks posttreatment. Inhibitory effects persisted through the 8-week evaluation period, with seedhead height reductions ranging from 42 to 26 percent that of the untreated control.

Overall plot appearance. Turf color was rated significantly lower than the untreated control with treatments of Embark + Escort, Escort + Manage, Royal Slo-Gro + 2,4-D, and Telar + Manage at 4 weeks posttreatment (Table 70). A slight discoloration, more specifically described as

leaf tip burn, was visible on either fescue alone (Embark + Escort, Royal Slo-Gro + 2,4-D and Telar + Manage) or on both fescue and bluegrass (Escort + Manage). As in previous years, fescue appeared more sensitive to chemical treatment than bluegrass. Despite initial discoloration, overall turf color never rated below the acceptable level for low- to medium-quality turfs. No differences in turf color were reported on subsequent evaluations.

Treatments of Limit + Banvel + 2,4-D, MON4625 + Banvel + 2,4-D, and Event + 2,4-D (in decreasing order of effectiveness) provided the longest period of acceptable control of weed species in 1989 (Table 71). Other treatments giving adequate weed control for up to 4 weeks posttreatment included: Embark + Escort, Escort + Manage, and Royal Slo-Gro + 2,4-D. With most treatments, weed control ratings declined with time. Overall, Shortstop + Banvel and Telar + Manage were least effective on weeds.

At 4 weeks posttreatment, only one treatment, Event + 2,4-D, showed a significantly higher turf quality rating compared to the untreated control (Table 72). A combination of positive PGR effects such as suppression of seedheads and vegetative growth, good broadleaf weed control, and no visible discoloration or turf thinning resulted in the success of this treatment. Embark + Escort, Escort + Manage, Royal Slo-Gro + 2,4-D, Shortstop + Banvel, and Telar + Manage also had acceptable turf quality (a rating ≥ 5) at this time; however, they were not significantly different from the control. By the next evaluation period, turf quality of all treatments rated unacceptable, indicating treatment effectiveness had dissipated to the point at which maintenance standards were not being met. None of the treatments produced effects that lowered turf quality below that of the untreated, unmowed control.

Chemical effectiveness was not as persistent for some treatments as in previous years. Duration of control for all but two PGR treatments in 1989 was 8 weeks (Figure 4). Treatments of Limit + Banvel + 2,4-D and MON4625 + Banvel + 2,4-D were least effective, controlling growth for only 4 weeks.

Discussion

According to Duell (1989), a successful PGR treatment for use on turfgrass must accomplish the following: (a) prevent seedhead formation without significant discoloration to the foliage, (b) produce temporary inhibitory effects that would not hinder turf recovery, and, (c) provide weed control by incorporating a herbicide to prevent release of associated weeds. Data collected at WGNAS also suggested these factors were most important when determining satisfactory treatment performance. Those PGR treatments that were most successful provided seedhead suppression, weed control, were effective long enough to be economically feasible, but not biologically detrimental, and did not produce objectionable discoloration.

Suppression of tall fescue seedheads appeared to be more important than controlling production of bluegrass inflorescences. This was probably due to the fact that, of the two, tall fescue was the dominant grass species and normally produces taller seedheads than bluegrass. Treatments that were not capable of reducing bluegrass seedhead numbers, but were effective at inhibiting bluegrass seedhead height, were often assessed acceptable.

Another observation noted throughout the study was the difference in chemical sensitivity among grass species. Differences in treatment effects between bluegrass and tall fescue were evident. For instance, Event + 2,4-D was a very effective seedhead inhibitor of tall fescue but not of bluegrass. Bluegrass seedhead heights were reduced by this treatment, but seedheads were not eliminated. The same phenomenon was noted with Royal Slo-Gro + 2,4-D. Turf discoloration with treatments of Embark + Escort and Telar + Manage also appeared more prevalent on tall fescue than on bluegrass. These differing effects suggest a variation in chemical tolerance between species. Species-specific activity with PGRs has been frequently reported in the literature (Beard 1973; Freeborg 1983; McElroy, Rieke, and McBurney 1984; Duell 1989). Both Freeborg (1983) and Danneberger and Street (1986) expressed the difficulty and importance of selecting the correct PGR treatment for use on mixed stands of turf, as a PGR may show differential activity for different grass species.

In addition to differences in chemical efficacy between species, time of seedhead development also varied among grass species. This period also varied slightly each year and was most likely influenced by climatic conditions. As a result, proper timing of application to maximize seedhead suppression becomes difficult when dealing with polystands. This was observed in the tests at WGNAS with tall fescue and bluegrass, as bluegrass seedhead production began before tall fescue. Variation in seedhead control from year to year may be explained by improper timing of application. For instance, in 1987 and 1989, none of the PGR treatments were effective at suppressing bluegrass seedhead emergence; however, several were effective on tall fescue. Evidently, bluegrass seedheads were too well-developed at the time of application to prevent emergence. In 1988, suppression of seedhead emergence was observed with both tall fescue and bluegrass, indicating treatments were effective and that chemical application was accomplished within the correct "window of application" for both species. McElroy, Rieke, and McBurney (1984) also reported variations in seedhead initiation among grass species in tests on roadside turf in Michigan. Understanding the phenology of each grass species is important for timing applications to maximize PGR activity.

Based on 3 years of data, the most successful PGR treatments evaluated at this location included Embark + Escort, Telar + Manage, Royal Slo-Gro + 2,4-D, MON4625 + Banvel + 2,4-D, Escort + Manage, and Event + 2,4-D, in order of decreasing effectiveness. Embark + Escort was the most consistent treatment tested, providing adequate broadleaf weed control and the longest periods of vegetative and seedhead control each year. Although Embark + Escort produced the most phytotoxic effects, discoloration was not

considered objectionable for medium- to low-quality turf. Telar + Manage, Royal Slo-Gro + 2,4-D, and MON4625 + Banvel + 2,4-D all provided good control, averaging 8 weeks of growth suppression over the 3-year period. In the case of Royal Slo-Gro + 2,4-D, new manufacturer label rates of application established in 1988 (rates were doubled) resulted in greater efficacy with this compound in the last 2 years of experimentation. Escort + Manage and Event + 2,4-D were fairly effective, maintaining acceptable turf quality for an average of 7 weeks. Limit + Banvel + 2,4-D and Shortstop + Banvel were the only treatments showing inconsistent results year after year. Shortstop + Banvel, a granular formulation, was described as producing very "spotty" control, resulting in an uneven-looking turf. The cause of these irregular effects may be attributed to an uneven distribution of the granules and/or lack of moisture to release chemical/granule activity. Watschke (1979) states the necessity for water to release the active, chemical ingredient as a possible drawback to granular formulations. Limit + Banvel + 2,4-D was a very efficient growth retardant in 1988 but showed poor results in 1987 and 1989. Inconsistent performance on tall fescue decreases the acceptance of this treatment for turf areas similar to WGNAS. Inconsistencies in turfgrass response to growth retardants is not uncommon (Christians 1985; McElroy, Rieke, and McBurney 1984).

Success with similar PGR applications on tall fescue and bluegrass have been reported in the literature. Field trials in North Carolina, evaluating 20 PGR treatments on Kentucky 31 tall fescue, showed that several compounds including ACP1911 (Event); amidochlor (Limit); Maleic hydrazide (Royal Slo-Gro); glyphosate (Manage); and mefluidide (Embark) were effective seedhead and foliar growth suppressants, and safe treatments with regard to turf quality and stand density (DiPaola and Lewis, 1987 and 1989). Miller and Eldridge (1989) reported reduced mowing of tall fescue turf with applications of maleic hydrazide. On Kentucky bluegrass, results of several studies show excellent growth regulation with mefluidide (Christians 1985; Bhowmik 1985; Watschke 1979), Limit (Kaufmann 1988; Bhowmik 1985), MON4624 (Bhowmik 1985), and Maleic hydrazide (Watschke 1979). Positive results have also been documented on tall fescue/Kentucky bluegrass turf mixtures (Wakefield and Fales 1980; Nielsen and Wakefield 1975). Temporary turf discoloration and loss of shoot density occurred with several growth retardants, but were not objectionable for roadside-type turfs (Wakefield and Fales 1980).

All treatments tested at WGNAS were tank-mixed combinations of a PGR and one or more herbicides. Tank mixes are common, economical, and recommended for areas where weeds are a component of the turf (McElroy, Rieke, and McBurney 1984; Beard 1973; Duell 1989; Freeborg 1983). Weed control is important to prevent encroachment of undesirable species as well as to maintain aesthetics. Unmanaged weeds in a growth-regulated turf reduced turf quality and provided a competitive advantage for weedy species. Some herbicides used at WGNAS were more effective than others, with the best broadleaf weed control observed when Escort and/or Banvel + 2,4-D were applied.

After 3 years of application, the only treatment showing a decline in turf density was Embark + Escort. Non-statistical, visual observations of vegetative cover recorded throughout the study indicated some reduction or thinning of tall fescue in these plots. Lewis and DiPaola (1987) also reported a reduction in tall fescue stand density with this treatment combination. However, when either product was applied alone, no significant reductions were observed. Synergistic effects were also reported by McElroy, Rieke, and McBurney (1984). In these studies, treatments of Embark + Telar produced better PGR results on tall fescue than when either product was used alone. Personal communication with grounds managers at Radford Army Arsenal, Radford, VA, reported no undesirable effects with Embark + Escort applications to tall fescue turfs after 3 years of use. No other detrimental effects to the turf, as a result of 3 years of treatment, were observed at WGNAS.

Conclusions

Results of this study lead to the following conclusions:

a. Based on 3 years of field tests, and considering all parameters evaluated, treatments that consistently performed the best on tall fescue/Kentucky bluegrass turf at WGNAS included: Embark + Escort, Telar + Manage, Royal Slo-Gro + 2,4-D, Escort + Manage, and Event + 2,4-D (in decreasing order of effectiveness). *Limit* + Banvel + 2,4-D and Shortstop + Banvel were least effective.

b. Seedhead suppression and weed control were the most important factors determining overall treatment success.

c. Broadleaf weed control is necessary to maintain aesthetics when treating mixed stands of turf with growth regulators. Escort and Banvel + 2,4-D were the most effective tank-mixed herbicides.

d. Timing of growth regulator application is critical to obtain grass seedhead suppression.

e. Growth regulators demonstrated varying responses on bluegrass and tall fescue, suggesting chemical-species specificity.

f. Repeat applications of Embark + Escort (3 consecutive years) may produce thinning of tall fescue in a tall fescue/Kentucky bluegrass turf.

g. Treatment efficacy varied annually depending on time of chemical application and prevailing weather conditions. Drought appeared to lengthen treatment effects.

h. Temporary turf discoloration can be expected from chemical treatments; however, effects are tolerable for low- to medium-quality turf areas.

6 Cost Comparison Analysis

In addition to identifying PGR efficacy, it is important to determine the cost-effectiveness of PGR use versus current maintenance practices. The primary objective for using growth-regulating compounds is to reduce the cost and frequency of mowing. Plant growth regulator application should be considered for only those land areas where substantial cost savings can be realized. It is also important to bear in mind that PGRs are part of a mowing management program and are rarely a substitute for mowing. To determine the cost-effectiveness of PGR use, several factors need to be considered:

a. Turf areas to be treated with PGRs.

b. Cost of mowing.

c. Cost of PGR application.

d. Expected duration of grass suppression as a result of PGR application.

Not all areas are amenable to PGR use. In general, areas described as medium- to low-quality turfs, also called utility turfs, are most suitable. The accepted level of aesthetic quality of these areas is often low, and slight discoloration (which is commonly associated with some PGR applications) can be tolerated. In addition, PGR use should be avoided on turfs subject to more than occasional traffic, highly managed aesthetic turfs, and newly seeded turfs.

Materials and Methods

Current grounds maintenance contracts and/or specifications from all participating installations were collected and reviewed. With the assistance of onsite personnel, information regarding type of maintenance activity including land-use description, acreage, mowing frequency, and mowing cost per acre was assembled (Tables 73-76). From this information, potential PGR application sites were identified for cost comparison analysis.

Potential PGR areas selected at the Charleston Naval Weapons Station included security fencelines and a large portion of the installation's ammunition storage area. Lands considered at Fort Leonard Wood included recreation areas, roadsides, training ranges, and golf course roughs. The airport runways and taxiways, also described as semi-improved lands, were recommended as potential PGR sites at Willow Grove Naval Air Station. Cost comparisons were estimated on three mowing categories maintained at various mowing frequencies at the Red River Army Depot and included areas such as: water and sewer plants, demolition areas, roadsides, fencelines, and fire lanes.

Mowing costs for all installations, with the exception of Willow Grove Naval Air Station, were obtained from 1988 grounds maintenance contracts. Cost figures are reported on a per acre basis and included labor, equipment, fuel, and all "hidden costs" pertaining to these items (e.g., insurance, labor benefits, etc.). At Willow Grove, all grounds maintenance operations are accomplished by government personnel rather than by private contractor; therefore, mowing costs were difficult to obtain. As a result, mowing costs for this location were estimated using US national averages obtained from *Means Landscape Cost Data* (R.S. Means Company, Inc. 1989). Chemical costs of products used in this study were acquired in 1988 and 1989 from the respective manufacturers (Table 77). Where a range in unit cost was reported, an average value (rounded to the nearest dollar) was used in all calculations. Pricing was not available for products under Experimental Use Permit or for products that had been removed from the market since study initiation. Cost of chemical application was estimated to equal the cost of one mowing per acre.

Based on 3 years data from the posttreatment plot evaluations, an average expected duration of chemical effectiveness was tabulated from Figures 1-4. The only exceptions were treatments with Royal Slo-Gro. In these instances, only the 1988 and 1989 data (and not a 3-year average) were used. The last 2 years of data represented results from applications made using the new and current labelled rate of application.

Using the aforementioned tables and figures, the mowing cost versus the cost if a PGR were applied to the same area were calculated for the candidate PGR sites (Tables 78-81). A 12-week time frame was used in the calculations and corresponds to the 12-week posttreatment evaluation period. The time frame also corresponds to spring months, as this is generally the best time to apply PGR treatments. All values were figured on a per acre basis to allow comparison between mowing categories. Costs were calculated as follows:

Example Location: Charleston Naval Weapons Station

Candidate Area For PGR Use: Level IA Section 1; Security Fenceline in Pomflant area (Table 73)

Total Acres: 18

1. To calculate the current grounds maintenance cost/acre:

Mowing Frequency: 2X/week; April-September (Table 73)

Mowing Cost Per Acre: $14.45 (Table 73)

Time Frame: 12 weeks (May, June, and July)

Maintenance Cost/Acre When Mowed

= Number of mowings in the 12-week period × Mowing cost/acre

= 24 mowings × $14.45

= $347.00

2. To calculate the maintenance cost/acre if a growth regulator was used:

PGR Treatment: Embark + Fusilade

Rate of Application: Embark @ 1.0 pt product/acre
Fusilade @ 6.0 oz product/acre (Table 37)

Cost of Chemical(s): Embark = $104.00/gal or $13.00/acre
Fusilade = $76.40/gal or $3.58/acre (Table 77)

Cost of Application: $14.45 (Cost of one mowing)

Average Duration of Chemical Control:

(4 weeks (1987) + 6 weeks (1988) + 6 weeks (1989))/3

= 5 weeks (Rounded to nearest whole number)

Time Frame: 12 weeks (May, June, and July)

Maintenance Cost/Acre If Embark + Fusilade Was Applied

= Cost of Chemical and Application + Cost of Mowing After Chemical Dissipation (Time Frame - Average Duration of Control)

= (13.00 + 3.58 + 14.45) + (12 wks - 5 wks (or Mowing for 7 wks))

= 31.03 + (14 mowings x 14.45)

= $233.00

Results and Discussion

Dollar figures from Tables 78-81 show that PGRs are an effective means of reducing grounds maintenance costs. Not all treatments showed direct cost savings, even though all treatments were effective at reducing mowing frequency. Cost differences between current mowing practices (mowing alone) and chemical treatments were most prevalent at the Charleston Naval Weapons Station followed by Red River Army Depot, Fort Leonard Wood, and Willow Grove Naval Air Station.

At Charleston, differences in the costs of current maintenance practices versus application of various PGR treatments ranged from 6 percent to 78 percent. In general, cost benefits were greater on lands maintained more frequently than once per month. This was demonstrated in mowing category III (Ammunition Storage; mowing frequency of 1X/month), where only applications with Oust were more cost-efficient than mowing. It should be noted, however, that the cost of using Event was approximately the same as mowing on this land area. Since results indicate treatments with Event reduced mowing by 67 percent, use of this product may be considered economical from the standpoint of reduced mowing activities alone. Mowing frequency was also reduced by all other treatments on this land category; however, product costs were prohibitive. Cost savings were greatest (averaging 57 percent) over all mowing categories with the use of Oust. Oust was not only inexpensive to apply, but also provided the longest period of growth control (10 weeks). Oust treatments reduced mowing requirements by 83 percent on land categories IA, II, and the non-contract mowed areas, and by 67 percent on Level III lands. Event, Royal Slo-Gro, and Embark + Oust also greatly reduced mowing. However, due to higher chemical pricing, these products were not as economical as Oust. Overall, the most cost-effective treatments evaluated at this location were Oust, Event, Embark + Oust, and Royal Slo-Gro.

On semi-improved grounds at Fort Leonard Wood, six treatments were cost-effective when compared to mowing alone. These treatments and respective percent dollars saved included: Event and Royal Slo-Gro + 2,4-D, 34 percent; Embark, Embark + Telar and Manage + Telar, 32 percent; and Embark + Escort, 29 percent. No cost benefits were realized on Category II; Improved lands, even though reductions in mowing were as high as 67 percent with several treatments. This can be attributed to the low mowing frequency ascribed to this area (1X/month) and an already low cost of current maintenance practices. Contractor cost for mowing golf course roughs was so inexpensive ($2.48/acre), that chemical application was not competitive. However, significant reductions in mowing frequency were observed; therefore, chemical treatment may be useful under some circumstances.

Embark + Escort and Telar + Manage proved to be the most cost-effective treatments compared to current mowing practices on the airport runways and taxiways at Willow Grove Naval Air Station. The differences in cost per acre as compared to mowing alone were 52 and 29 percent, respectively.

Note that these cost savings would transpire during the time period between April and June, when the mowing frequency of this area is at its highest. Later in the season when the mowing frequency decreases to 1X/month, the cost-effectiveness of using PGRs would likely diminish. Escort + Manage, Royal Slo-Gro, and Event + 2,4-D were also effective, averaging 10 percent lower costs than mowing.

Cost estimates of chemical application versus biweekly mowing on Type I grounds at the Red River Army Depot showed that all chemical treatments exhibited lower costs per acre as compared to mowing alone. Cost savings ranged from 5 percent to 55 percent that of mowing, with Roundup + Oust being the most economical product evaluated. Roundup + Oust also reduced mowing by 83 percent. Two treatments showed some cost savings on monthly mowed areas. Cost differences per acre (as compared to mowing alone) averaged 15 percent. Again, areas maintained at a higher frequency were also those areas that showed the greatest cost benefit through the use of PGRs.

Overall, results indicate that PGRs can be used as a cost-effective tool in grounds maintenance. Generally, areas that were mowed at a higher frequency than 1X/month showed the greatest cost savings. In many instances, the cost of chemical use per acre was the same (± $1-5) as that of current mowing operations. In these instances, careful consideration of mowing versus PGR use is needed. Even though dollar for dollar the costs are similar, choosing to use PGRs may be the best maintenance option especially if the area under consideration is difficult and/or dangerous to mow, within a high-security area, or requires frequent mowing. This would be of particular interest or areas such as ammunition storage magazines. Frequent use of mowing equipment on these structures is not only expensive, but often increases the risk of damage to the vegetative cover, subsequently causing soil erosion problems. The costs of structural repair and vegetation reestablishment as a result of mower damage are added expenses to the grounds maintenance budget. Other indirect cost savings as a result of reduced mowing include manpower reallocation and less wear and tear on equipment. In other words, the cost benefits of PGR use may be measured in many ways: dollars; labor reassignment; reduced safety hazards; and/or reduced use of mowing equipment on erosion-sensitive areas.

Conclusions

The following can be concluded about the cost-effectiveness of PGR treatments versus current mowing practices:

a. On the land areas selected as candidate PGR application sites, cost comparison analysis showed that most of the plant growth regulator treatments evaluated were cost-effective when compared to standard mowing practices.

b. At each test site, mowing reductions were realized with all chemical treatments evaluated.

c. Generally, semi-improved grounds mowed at least once per month showed the greatest cost savings.

7 Recommendations

General Recommendations

Use areas

An assessment to determine whether turf areas are amenable to PGR applications should be completed by identifying area maintenance objectives such as aesthetic and use requirements and mowing frequency. Areas described as medium- to low-quality turfs or semi-improved grounds, are most suitable for PGR use. Examples of these areas include roadsides, levees, low-use park areas, golf course roughs, ammunition storage magazines, cantonement areas, fencelines, and grass areas adjacent to airport runways and taxiways. The accepted level of aesthetic quality of these areas is low, and slight discoloration, which is a commonly associated with some PGR applications, can be tolerated. PGR use should be avoided on turf subject to more than occasional traffic (ball fields), highly managed turfs (around living quarters and administration buildings), and newly seeded turfs. It is important to remember that PGRs can be a supplement to a mowing management program, but rarely are a substitute for mowing.

Timing of application

Timing of PGR application is critical, and is often the difference between success and failure. For example, with cool-season grasses, such as bluegrass, the best time to apply a growth regulator is in the spring, when grasses are green, rapidly growing, and before seedheads emerge. This time span is termed the "window of application," and represents the period of maximum PGR effectiveness and economic benefit. The window varies among grass species and is influenced each year by weather. If grass seedhead suppression is a desired goal of chemical application, growth regulators must be applied prior to seedhead emergence. Consulting turf specialists, county extension agents, and product labels will help identify the most appropriate application date for each turf situation.

Product selection

Most PGRs are species specific, affecting each grass species (and sometimes even cultivars) to a different degree. Therefore, it is important to know which product(s) will provide the desired effects. In addition, many PGRs are not effective on broadleaf weed species. Selecting the proper products and determining rates of application become increasingly important when dealing with mixed stands of turf. Areas described as semi-improved grounds are often a mixture of desired, managed grass species and a variety of weedy species. Many of these areas are subject to weed encroachment if growth of the desired grass is suppressed by a PGR. In this situation, using a PGR/herbicide combination to integrate weed control with growth regulation is of benefit. Product labels should always be read and/or manufacturers should be contacted for specific guidance on intended use. If weeds are a component of the turf area, PGR/herbicide tank mixes should be considered. Many PGR labels recommend compatible herbicides or other growth regulators that can be used as tank mixes. Evaluating the performance of PGR and PGR/herbicide combinations on small plots (<1 acre (0.40468 ha)) should be considered prior to treating large areas. Small-plot testing will familiarize grounds managers with product effectiveness as well as application timing and technique.

Application technique

Proper equipment, calibration, and method of application are important factors to consider to obtain desired effects. Product labels and application guidance should be read thoroughly. Common application mistakes, such as overlapping spray patterns and skipping areas, can produce unsatisfactory results and possibly damage turf. Trained, licensed applicators should always be used and application operations should be monitored. Follow-up site inspections should be conducted to evaluate product efficacy and to identify any problems from PGR treatment. Monitoring results will enhance future treatments. Grounds maintenance contracts must also allow flexibility to accommodate temporary reductions in mowing frequency as dictated by PGR performance.

Monitor treatments

If turf thinning, undesirable changes in species composition, or any other detrimental effect develops after several years of chemical application, product use should be discontinued and turf should be allowed to recover. Rotating a PGR treatment with a mowing program (treat 1 year, mow the next, etc.) may be feasible.

Site-Specific Recommendations

Fort Leonard Wood

The products Embark + Telar and Embark + Escort are recommended as the best treatments for use at Fort Leonard Wood. Other appropriate (cost-effective but less active) treatments that can be used include: Royal Slo-Gro + 2,4-D, Event, and Manage + Telar. If Event is used, it should be applied with a broadleaf herbicide to provide additional weed control. Land areas recommended for growth regulator treatment at Fort Leonard Wood include the following mowing categories:

a. Type I; semi-improved; maintained 2X/month.

b. Type II; improved; maintained 1X/month.

c. Golf course roughs.

A pre-treatment mowing is recommended if turf is not at a uniform, acceptable height at the time of growth regulator treatment.

Recommended treatments should be applied prior to bluegrass and tall fescue seedhead emergence (generally early April, when dandelions and forsythia shrubs are in bloom). Treatments should not be applied if tall fescue seedheads have emerged, as unsatisfactory chemical performance and/or little or no cost savings will result.

Red River Army Depot

The products Roundup + Oust and Oust + Escort are recommended for use at RRAD. Where weed problems are not severe, Arsenal can also be used. Recommended treatments should be applied to semi-improved grounds or those areas described as low- to medium-quality turfs. At RRAD, these areas are found in the following mowing categories:

a. Type I; hand rotary-mowed areas; maintained 2X/month.

b. Type II; hand rotary-mowed areas; maintained 1X/month.

c. Type II; bushhog mowing; maintained 1X/month.

Apply Roundup + Oust and Oust + Escort in the spring when bermudagrass and weed species are green and actively growing. Arsenal must be applied before bermudagrass greens up (generally, early March at this location).

Due to the long growing season for warm-season grasses, more than one chemical application per growing season may be economically feasible. Additional research to identify the effects and cost benefits of multiple or sequential applications in one growing season is needed.

Charleston Naval Weapons Station

The products Oust, Event, and Royal Slo-Gro are recommended for use at CNWS. Lands at CNWS that should be considered for PGR use include:

a. Pomflant security fencelines, Level IA, Section 1 (use either Oust, Event, or Royal Slo-Gro).

b. Pomflant critical and limited areas, Level II and the additional security areas mowed by government forces (use Oust).

c. Ammunition storage areas, Level III (use Oust or Event).

Applications should be made in accordance with product labelling and prior to seedhead emergence to maximize seedhead suppression. If at the time of application, bahiagrass seedheads are beginning to emerge or in the boot stage, a pre- or posttreatment mowing (~5 days before or after application) is required. Mowing will remove those seedheads that are present at the time of application or those near emergence that escape chemical activity.

If weeds are a problem on areas to be treated, consider tank-mixing additional weed-control products with the PGR treatments recommended in item *a*. Consult product labels and/or respective manufacturers for compatible herbicides.

Willow Grove Naval Air Station

A tank-mixed treatment of Embark + Escort is recommended for use at WGNAS. ***CAUTION***: If undesirable turf thinning occurs after several (3) years of treatment with Embark + Escort, product use should be discontinued to allow turf recovery. Other appropriate treatments for this location include Telar + Manage or Royal Slo-Gro + 2,4-D. Recommended treatments should be applied only to semi-improved grounds at WGNAS, which include the grassed areas adjacent to airport runways and taxiways, also referred to as mowing category 0157. A pre-treatment mowing is recommended if turf is not at a uniform, acceptable height at the time of PGR treatment.

Broadleaf weed control is required for satisfactory results with growth regulators at this location. All aforementioned recommended treatments include herbicides for weed control; however, other herbicides may be substituted if the PGR label designates product compatibility.

Recommended treatments should be applied prior to bluegrass and tall fescue seedhead emergence (generally early to mid April, when dandelions and Forsythia shrubs are in bloom). Treatments should not be applied if tall fescue seedheads have emerged or are near emergence, as unsatisfactory chemical performance and/or little or no cost savings will result.

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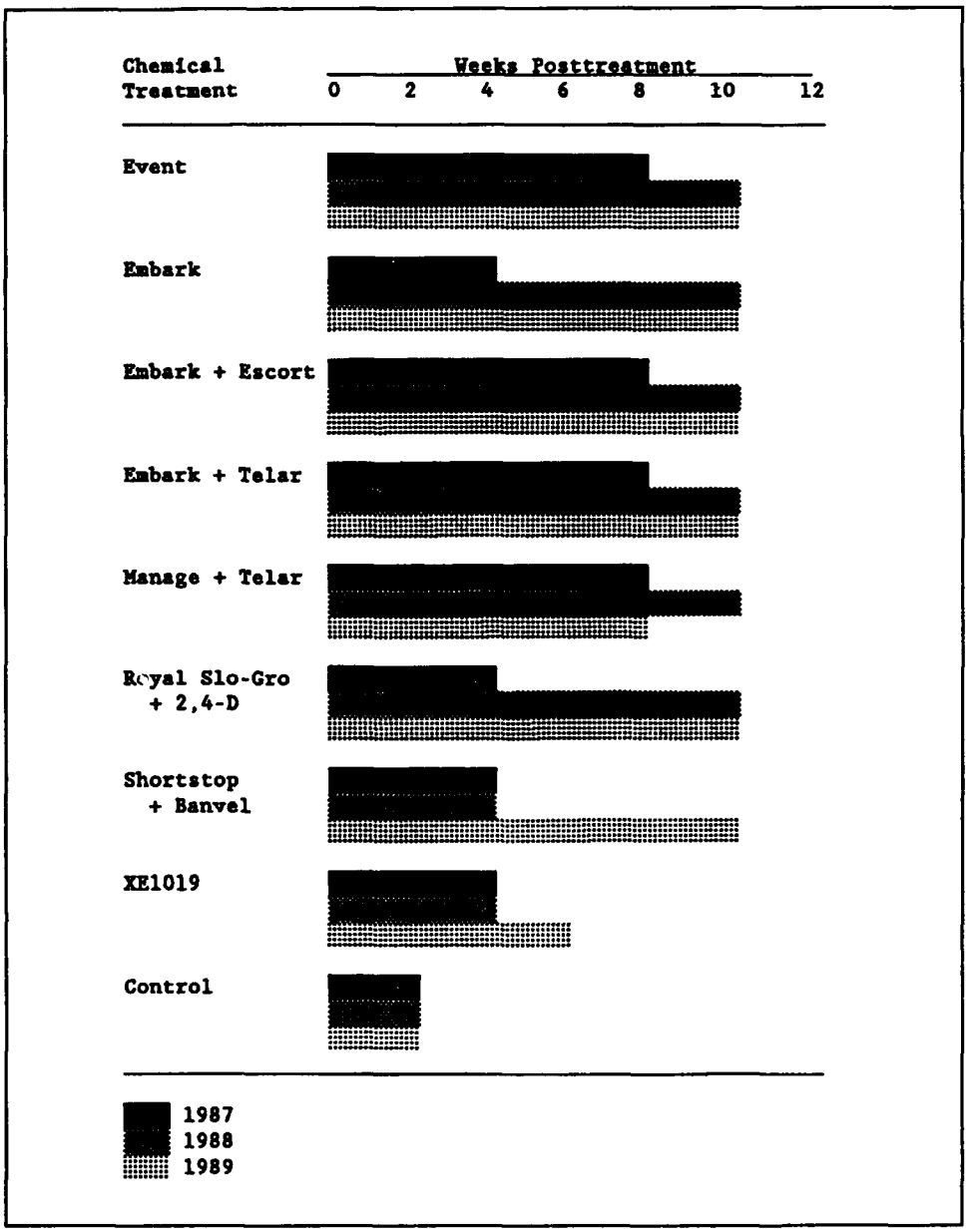

Figure 1. Duration of acceptable vegetation control with the use of PGR compounds at Fort Leonard Wood, MO

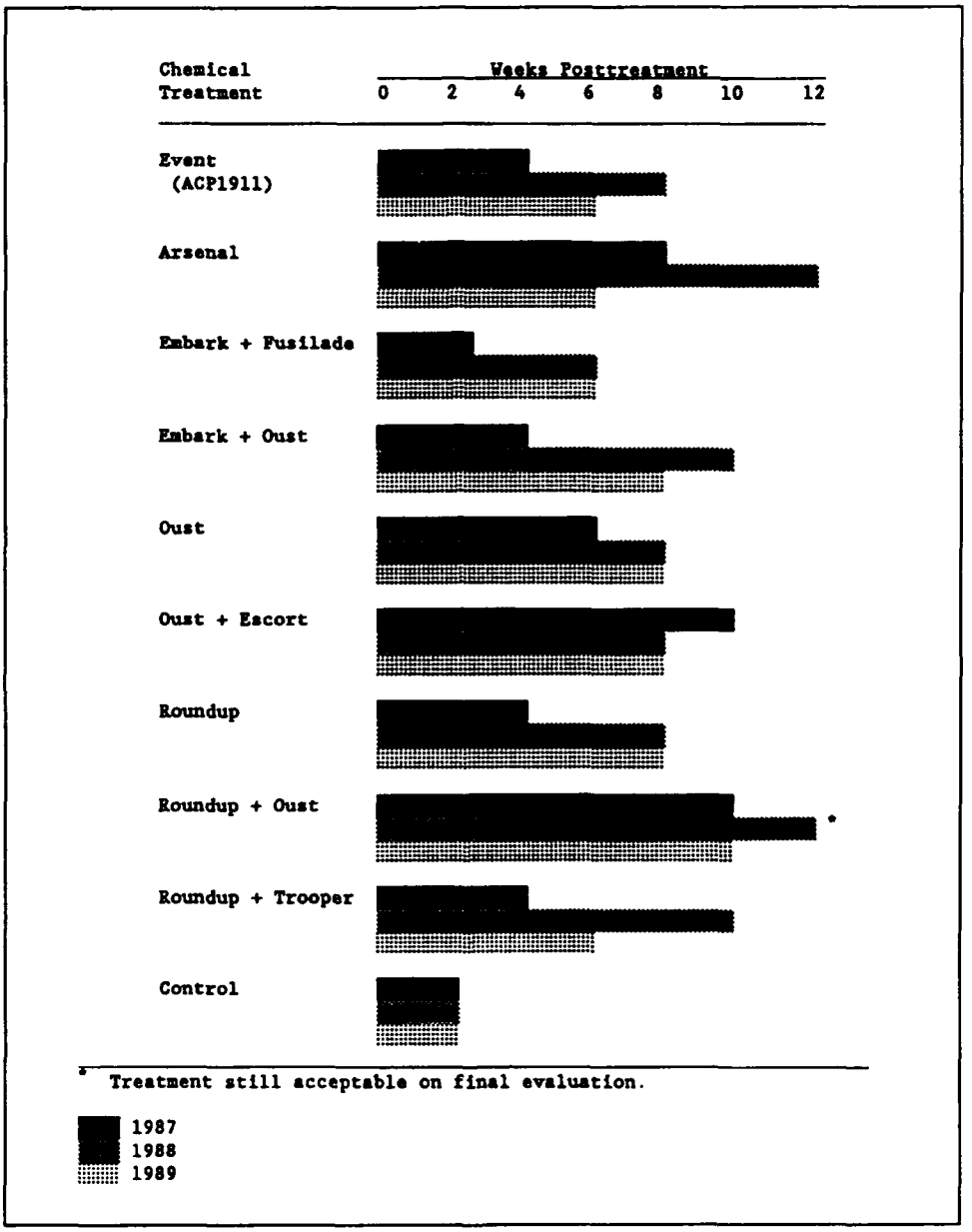

Figure 2. Duration of acceptable vegetation control with the use of PGR compounds at Red River Army Depot, Texarkana, TX

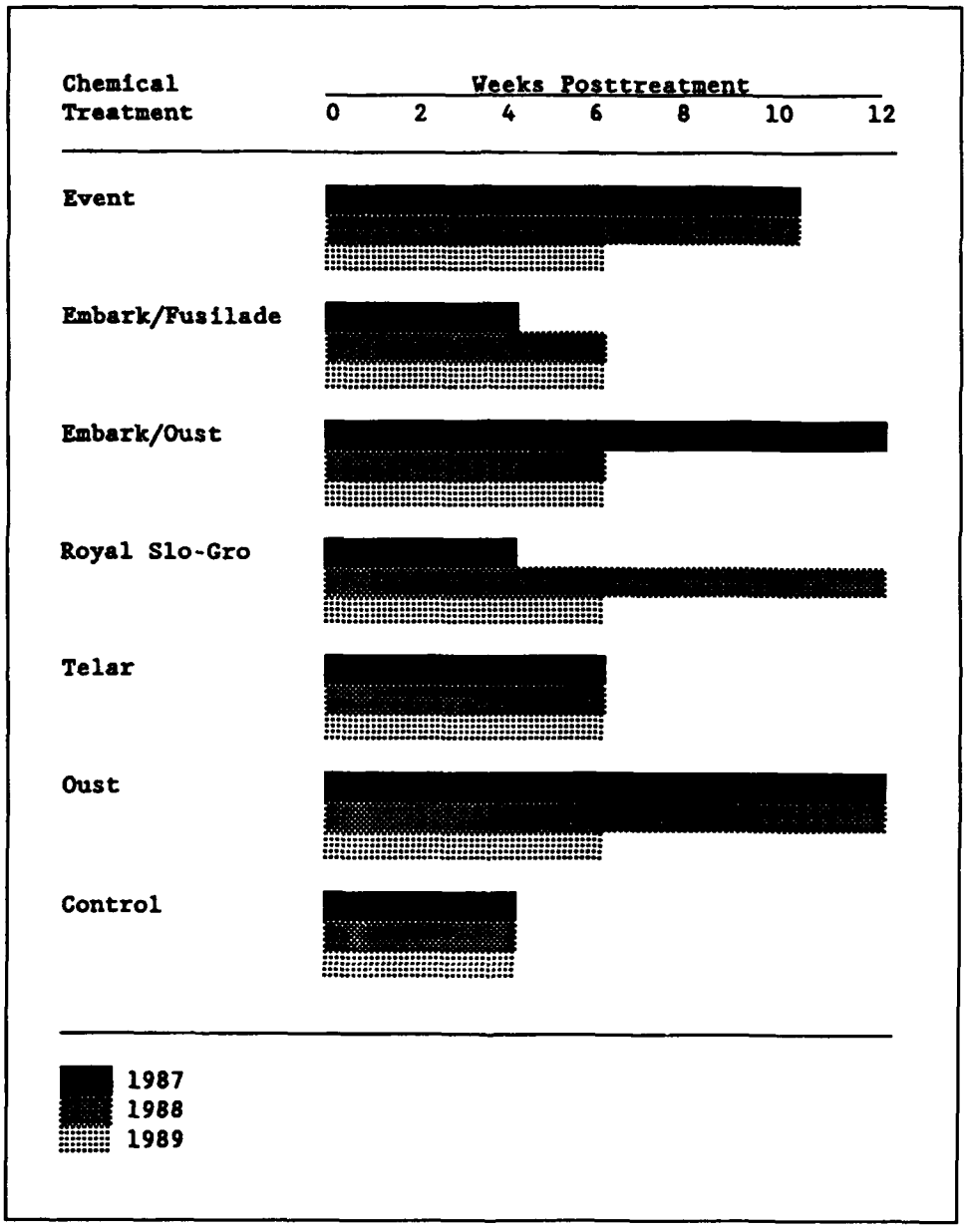

Figure 3. Duration of acceptable vegetation control with the use of PGR compounds at Charleston Naval Weapons Station, Charleston, SC

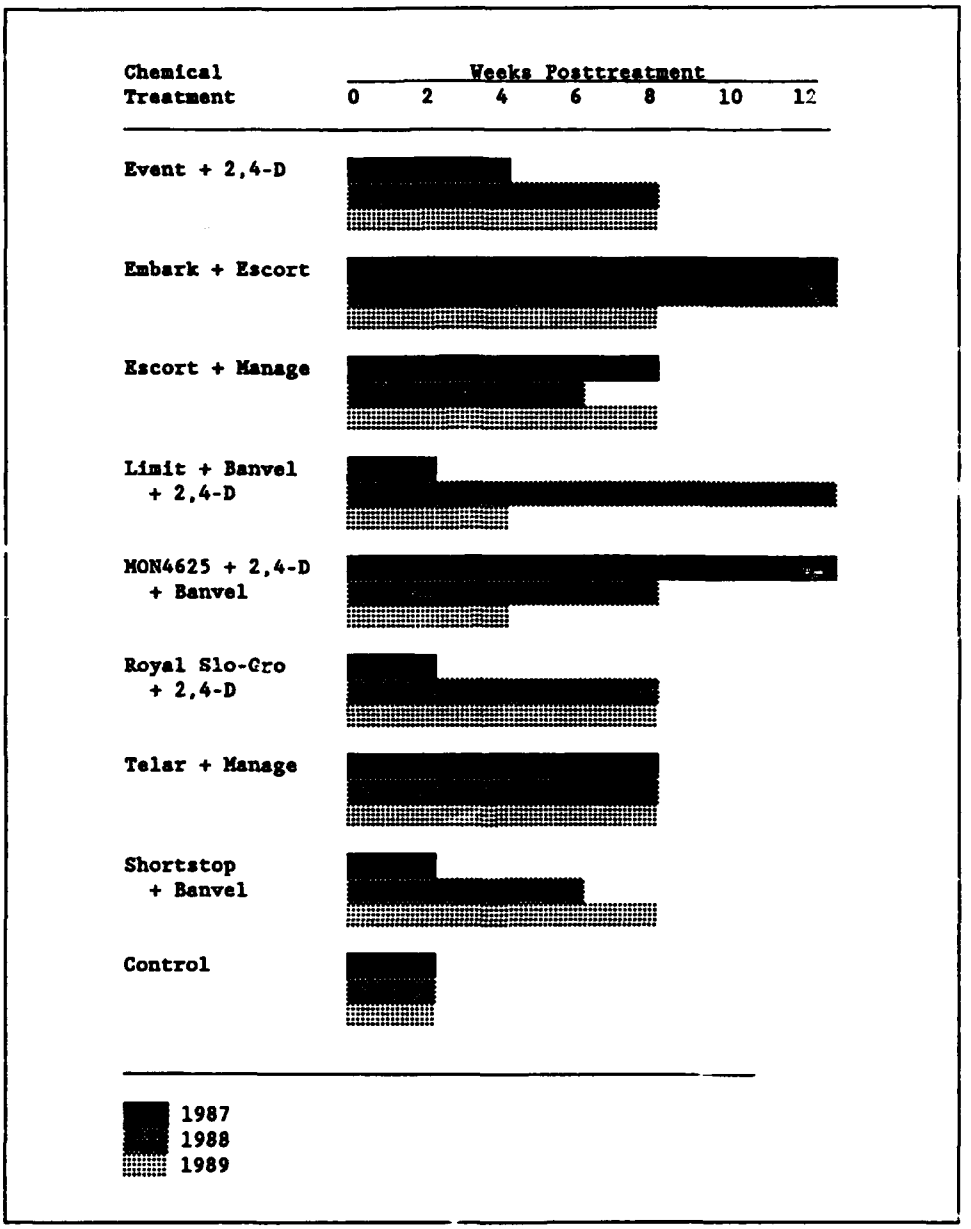

Figure 4. Duration of acceptable vegetation control with the use of PGR compounds at Willow Grove Naval Air Station, Willow Grove, PA

Table 1
Plant Growth Regulator Treatments and Rates of Application at Fort Leonard Wood, MO. Dates of Application: 22-23 April 1987; 13-14 April 1988; 5 April 1989

Treatment	Rate	
	Product/ha	Product/acre
Event[1] + X-77 (surfactant)	95.81 ml 0.25 % v:v[2]	8.00 oz 0.25 % v:v
Embark	287.20 ml	1.50 pt
Embark + Escort	191.55 ml 3.99 ml	1.00 pt 0.33 oz
Embark + Telar	191.55 ml 3.99 ml	1.00 pt 0.33 oz
Manage + Telar	47.91 ml 5.99 ml	4.00 oz 0.50 oz
Royal Slo-Gro + 2,4-D	3.56 L 7.13 L 0.83 L	2.00 gal (1987) 4.00 gal (1988)[3] 1.00 qt
Shortstop + Banvel	14.70 kg 1.84 kg	80.00 lb 10.00 lb
XE1019	367.61 g	2.00 lb

[1] Formerly experimental use product ACP1911.
[2] Percent volume to volume of the spray mixture.
[3] New product label rate imposed in 1988.
NOTE: To calculate treatment rate based on active ingredient, use Appendix B.

Table 2
Mean Vegetative Height of Tall Fescue at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 22-23 April 1987

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	13.7[c1]	14.2[c]	17.9[b]	23.9[b]	--	--
Embark	20.5[b]	22.2[b]	--[2]	--	--	--
Embark + Escort	14.8[c]	14.8[c]	19.4[b]	26.2[b]	--	--
Embark + Telar	14.8[c]	13.8[c]	15.5[b]	23.8[b]	--	--
Manage + Telar	15.4[c]	14.0[c]	17.4[b]	24.4[b]	--	--
Royal Slo-Gro + 2,4-D	19.4[b]	19.9[b]	--	--	--	--
Shortstop + Banvel	20.5[b]	20.5[b]	--	--	--	--
XE1019	24.2[a]	26.8[a]	--	--	--	--
Control	25.8[a]	27.7[a]	30.4[a]	34.0[a]	--	--
BLSD (0.05)	1.70	3.51	6.20	2.96		

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] Height measurements were not recorded once treatments were assessed unacceptable.

Table 3
Mean Seedhead Height of Tall Fescue at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 22-23 April 1987

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0[d1]	0.0[c]	0.0[c]	0.0[b]	--	--
Embark	35.7[bc]	49.6[ab]	--[2]	--	--	--
Embark + Escort	0.0[d]	11.4[c]	31.2[b]	15.2[b]	--	--
Embark + Telar	0.0[d]	15.3[c]	41.2[b]	0.0[b]	--	--
Manage + Telar	27.7[c]	18.8[c]	39.9[b]	27.4[b]	--	--
Royal Slo-Gro + 2,4-D	25.2[c]	20.0[bc]	--	--	--	--
Shortstop + Banvel	39.7[b]	52.0[a]	--	--	--	--
XE1019	45.8[ab]	59.2[a]	--	--	--	--
Control	56.0[a]	74.0[a]	71.6[a]	83.6[a]	--	--
BLSD (0.05)	11.81	29.95	23.41	28.58		

[1] Means in the same column followed by the same letter are not significantly different at $P = 0.05$ level of the BLSD test.
[2] Height measurements were not recorded once treatments were assessed unacceptable. In addition, all plots were mowed after the 8-week posttreatment evaluation, therefore no measurements were recorded after this point.

Table 4
Mean Vegetative Height of Kentucky Bluegrass at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 22-23 April 1987

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	12.7	13.7[c1]	15.2	16.5[bc]	--	--
Embark	15.2	16.6[bc]	--[2]	--	--	--
Embark + Escort	14.9	12.8[c]	16.3	19.6[ab]	--	--
Embark + Telar	16.2	13.4[c]	15.6	20.0[ab]	--	--
Manage + Telar	14.3	12.8[c]	14.4	14.8[c]	--	--
Royal Slo-Gro + 2,4-D	15.6	18.6[ab]	--	--	--	--
Shortstop + Banvel	14.6	15.9[bc]	--	--	--	--
XE1019	17.5	21.0[a]	--	--	--	--
Control	15.0	21.4[a]	18.7	21.8[a]	--	--
BLSD (0.05)	NS	3.94	NS	4.59	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] Height measurements were not recorded once treatments were assessed unacceptable. In addition, all plots were mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.
NS = Not significant.

Table 5
Mean Seedhead Height of Kentucky Bluegrass at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 22-23 April 1987

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	23.2[c1]	23.3[ab]	25.8[b]	20.7[b]	--	--
Embark	21.8[c]	23.5[ab]	--[2]	--	--	--
Embark + Escort	16.7[d]	12.3[b]	20.6[b]	0.0[c]	--	--
Embark + Telar	15.2[d]	14.6[b]	19.6[b]	31.0[ab]	--	--
Manage + Telar	13.7[d]	16.2[b]	16.0[b]	0.0[c]	--	--
Royal Slo-Gro + 2,4-D	34.5[ab]	35.6[a]	--	--	--	--
Shortstop + Banvel	14.8[d]	13.8[b]	--	--	--	--
XE1019	31.4[b]	31.9[a]	--	--	--	--
Control	38.0[a]	35.8[a]	38.0[a]	39.6[a]	--	--
BLSD (0.05)	4.70	14.16	11.35	17.37		

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] Height measurements were not recorded once treatments were assessed unacceptable. In addition, all plots were mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.

Table 6
Mean Vegetative Height of Tall Fescue at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 13-14 April 1988

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	16.9	15.4[d1]	..[2]	21.8[bc]	24.4	26.6
Embark	21.7	20.1[b]	..	24.0[abc]	26.2	24.9
Embark + Escort	18.9	16.3[cd]	..	24.0[abc]	29.6	25.5
Embark + Telar	18.6	15.6[d]	..	22.7[bc]	25.3	26.0
Manage + Telar	15.8	15.5[d]	..	20.6[bc]	24.6	23.7
Royal Slo-Gro + 2,4-D	21.7	19.0[bc]	..	19.6[c]	24.0	23.7
Shortstop + Banvel	19.4	18.7[bc]	..	23.7[abc]	24.3	23.8
XE1019	20.9	23.9[a]	..	25.5[ab]	29.0	24.2
Control	21.6	26.2[a]	..	28.6[a]	28.5	26.7
BLSD (0.05)	NS	2.95	..	5.33	NS	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] No evaluations were performed at 6 weeks posttreatment.
NS = Not significant.

Table 7
Plant Growth Regulator Effects on Seedhead Number at Fort Leonard Wood, MO. Treatment Date = 13-14 April 1988

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2					
	Tall Fescue			Kentucky Bluegrass		
	4 wk	8 wk	12 wk	4 wk	8 wk	12 wk
Event	0.0^{c}[1]	0.0^{c}	..[2]	58.6^{ab}	68.6^{ab}	..
Embark	4.3^{c}	37.1^{b}	..	65.7^{abc}	42.9^{bc}	..
Embark + Escort	1.4^{c}	1.4^{c}	..	5.7^{c}	1.4^{c}	..
Embark + Telar	0.0^{c}	1.4^{c}	..	20.0^{bc}	14.3^{c}	..
Manage + Telar	4.3^{c}	57.1^{b}	..	27.1^{bc}	4.3^{c}	..
Royal Slo-Gro + 2,4-D	0.0^{c}	0.0^{c}	..	75.7^{ab}	84.3^{a}	..
Shortstop + Banvel	114.3^{a}	117.1^{a}	..	78.6^{ab}	97.1^{a}	..
XE1019	74.3^{ab}	145.7^{a}	..	124.3^{a}	127.1^{a}	..
Control	47.1^{b}	110.0^{a}	..	132.9^{a}	100.0^{a}	..

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] No viable seedheads were present at 12 weeks posttreatment.

Table 8
Mean Seedhead Height of Tall Fescue at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 13-14 April 1988

	Seedhead Height (Weeks Posttreatment), cm					
Chemical Treatment	**2 wk**	**4 wk**	**6 wk**	**8 wk**	**10 wk**	**12 wk**
Event	0.0	0.0[c1]	--[2]	0.0[d]	36.8[bcd]	--
Embark	0.0	16.2[b]	--	56.7[bc]	65.4[abc]	--
Embark + Escort	0.0	0.0[c]	--	0.0[d]	42.1[bcd]	--
Embark + Telar	0.0	0.0[c]	--	13.8[d]	32.4[cd]	--
Manage + Telar	0.0	22.9[b]	--	51.5[c]	55.8[abcd]	--
Royal Slo-Gro + 2,4-D	0.0	0.0[c]	--	0.0[d]	18.7[d]	--
Shortstop + Banvel	0.0	32.4[a]	--	69.4[ab]	75.2[ab]	--
XE1019	0.0	33.2[a]	--	77.2[a]	77.5[ab]	--
Control	0.0	34.9[a]	--	80.6[a]	85.9[a]	--
BLSD (0.05)	NS	9.33	--	15.16	42.54	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] No evaluations were performed at 6 weeks posttreatment. No viable seedheads were present for measurement at 12 weeks posttreatment.
NS = Not significant.

Table 9
Mean Vegetative Height of Kentucky Bluegrass at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 13-14 April 1988

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	15.1	14.9[b1]	--[2]	19.0[bc]	17.5	21.2[a]
Embark	14.2	17.3[ab]	--	21.5[abc]	16.1	20.4[a]
Embark + Escort	14.8	15.2[b]	--	22.4[ab]	25.4	22.3[a]
Embark + Telar	13.8	14.7[b]	--	20.0[bc]	19.5	21.0[a]
Manage + Telar	12.6	14.6[b]	--	17.2[c]	16.5	16.3[b]
Royal Slo-Gro + 2,4-D	15.1	16.5[ab]	--	19.4[bc]	16.4	19.7[ab]
Shortstop + Banvel	13.2	16.4[ab]	--	18.5[bc]	17.9	18.7[ab]
XE1019	14.8	20.5[a]	--	23.0[ab]	18.9	20.2[ab]
Control	15.1	19.7[a]	--	25.4[a]	18.7	21.8[a]
BLSD (0.05)	NS	4.44	--	5.03	NS	4.06

[1]Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] No evaluations were performed at 6 weeks posttreatment.
NS = Not significant.

Table 10
Mean Seedhead Height of Kentucky Bluegrass at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 13-14 April 1988

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0[d1]	19.4[abc]	..[2]	22.4[cd]	24.5	..
Embark	6.2[c]	14.6[c]	..	12.7[de]	23.9	..
Embark + Escort	0.0[d]	7.8[c]	..	0.0[f]	14.1	..
Embark + Telar	0.0[d]	17.4[bc]	..	8.5[ef]	28.9	..
Manage + Telar	0.0[d]	16.9[bc]	..	0.0[f]	23.4	..
Royal Slo-Gro + 2,4-D	12.7[b]	22.1[abc]	..	19.6[de]	29.4	..
Shortstop + Banvel	6.1[c]	20.5[abc]	..	31.1[bc]	29.7	..
XE1019	17.1[ab]	33.0[ab]	..	34.1[ab]	32.4	..
Control	19.3[a]	35.7[a]	..	43.0[a]	40.8	..
BLSD (0.05)	5.47	17.33	..	11.17	NS	..

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] No evaluations were performed at 6 weeks posttreatment. No viable seedheads were present for measurement at 12 weeks posttreatment.
NS = Not significant.

Table 11
Plant Growth Regulator Effects on Weed Control at Fort Leonard Wood, MO. Treatment Date = 13-14 April 1988

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	5.7^{ab2}	3.3^{dc}	..[3]	3.3^{c}	2.3^{bc}	2.3^{bc}
Embark	5.7^{ab}	1.3^{de}	--	1.3^{d}	4.0^{abc}	1.7^{cd}
Embark + Escort	6.3^{ab}	6.0^{a}	--	6.7^{a}	7.0^{a}	5.3^{a}
Embark + Telar	6.3^{ab}	4.8^{abc}	--	5.0^{b}	4.3^{abc}	3.3^{b}
Manage + Telar	8.0^{a}	5.8^{ab}	--	5.0^{b}	3.0^{bc}	3.3^{b}
Royal Slo-Gro + 2,4-D	7.3^{a}	6.5^{a}	--	6.5^{a}	6.0^{b}	4.7^{a}
Shortstop + Banvel	6.0^{ab}	3.8^{bc}	--	3.8^{bc}	3.3^{abc}	2.3^{bc}
XE1019	3.7^{bc}	1.0^{e}	--	1.0^{d}	1.7^{c}	1.3^{cd}
Control	1.0^{c}	1.0^{e}	--	1.0^{d}	1.0^{c}	1.0^{d}
BLSD (0.05)	3.38	2.03	--	1.27	3.91	1.30

[1] Weed control was evaluated using a visual scale of 1-9 where 1 = no chemical effect, 5 = minimally acceptable, 9 = excellent, no weeds present.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[3] No evaluation performed at 6 weeks posttreatment.

Table 12
Plant Growth Regulator Effects on Turf Color at Fort Leonard Wood, MO. Treatment Date = 13-14 April 1988

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	6.7[a2]	6.3[c]	..[3]	6.7[ab]	7.0[ab]	5.7[ab]
Embark	7.0[a]	7.5[ab]	--	6.0[bc]	6.0[ab]	6.0[ab]
Embark + Escort	5.7[ab]	5.3[d]	--	6.0[bc]	6.7[ab]	7.0[a]
Embark + Telar	6.3[a]	6.3[c]	--	6.7[ab]	7.3[a]	6.0[ab]
Manage + Telar	3.7[b]	4.2[e]	--	5.0[c]	3.7[c]	5.7[ab]
Royal Slo-Gro + 2,4-D	8.0[a]	7.5[ab]	--	7.0[ab]	6.3[ab]	5.7[ab]
Shortstop + Banvel	7.7[a]	6.7[bc]	--	6.0[bc]	5.3[bc]	4.7[b]
XE1019	8.0[a]	8.0[a]	--	7.8[a]	5.7[ab]	5.0[b]
Control	8.0[a]	8.0[a]	--	8.0[a]	5.7[ab]	5.0[b]
BLSD (0.05)	2.38	1.00	--	1.46	1.94	1.36

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[3] No evaluation performed at 6 weeks posttreatment.

Table 13
Plant Growth Regulator Effects on Turf Quality at Fort Leonard Wood, MO. Treatment Date = 13-14 April 1988

Chemical Treatment	Turf Quality (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	6.7[a2]	7.0	--[3]	6.0[ab]	4.7[a]	4.0[ab]
Embark	6.7[a]	6.7	--	5.0[b]	4.0[a]	3.7[ab]
Embark + Escort	6.3[ab]	6.3	--	6.7[a]	5.3[a]	4.7[a]
Embark + Telar	7.0[a]	7.0	--	5.7[ab]	5.0[a]	3.3[b]
Manage + Telar	4.3[b]	5.0	--	4.7[bc]	2.7[a]	3.0[b]
Royal Slo-Gro + 2,4-D	7.7[a]	7.7	--	6.7[a]	5.0[a]	4.0[ab]
Shortstop + Banvel	7.7[a]	5.0	--	3.5[c]	2.7[a]	3.0[b]
XE1019	7.3[a]	4.7	--	3.3[c]	3.0[a]	3.3[b]
Control	7.7[a]	4.3	--	3.3[c]	3.0[a]	3.0[b]
BLSD (0.05)	2.02	2.27	--	1.39	3.18	1.22

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf, 5 = minimally acceptable, mowing not yet required, 9=best quality, optimum greenness, density, and uniformity with excellent vegetative and seedhead suppression and weed control.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[3] No evaluation performed at 6 weeks posttreatment.

Table 14
Mean Vegetative Height of Tall Fescue at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 5 April 1989

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	14.1[bcd1]	12.9[c]	14.4[c]	19.9	22.2[bc]	23.9
Embark	15.5[abc]	16.2[b]	16.9[abc]	19.6	22.7[bc]	25.0
Embark + Escort	11.5[d]	12.4[c]	15.3[bc]	20.7	25.9[ab]	27.5
Embark + Telar	13.3[cd]	12.0[c]	13.8[c]	20.7	21.1[c]	24.8
Manage + Telar	14.4[bc]	11.9[c]	14.5[c]	18.3	20.6[c]	24.5
Royal Slo-Gro + 2,4-D	15.4[abc]	16.9[b]	18.2[ab]	20.3	23.4[abc]	24.1
Shortstop + Banvel	15.5[abc]	16.3[b]	15.6[bc]	18.8	21.9[bc]	25.9
XE1019	16.8[ab]	21.6[a]	19.6[a]	20.7	24.7[abc]	23.9
Control	17.0[a]	21.0[a]	19.3[a]	22.3	27.5[a]	25.5
BLSD (0.05)	2.86	2.49	3.55	NS	4.70	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 15
Plant Growth Regulator Effects on Seedhead Number at Fort Leonard Wood, MO. Treatment Date = 5 April 1989

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2					
	Tall Fescue			Kentucky Bluegrass		
	4 wk	8 wk	12 wk	4 wk	8 wk	12 wk
Event	0.0	28.6^{b1}	8.6^{c}	44.3^{ab}	95.7^{ab}	65.7^{abc}
Embark	0.0	21.4^{b}	7.1^{c}	5.7^{cd}	25.7^{ab}	2.9^{c}
Embark + Escort	0.0	0.0^{c}	1.4^{c}	24.3^{bc}	47.1^{ab}	12.9^{bc}
Embark + Telar	0.0	0.0^{c}	0.0^{c}	24.3^{bc}	68.6^{a}	31.4^{abc}
Manage + Telar	0.0	87.1^{a}	54.3^{b}	30.0^{bc}	44.3^{ab}	30.0^{abc}
Royal Slo-Gro + 2,4-D	0.0	27.1^{b}	37.1^{b}	7.1^{cd}	40.0^{ab}	32.9^{abc}
Shortstop + Banvel	0.0	45.7^{b}	15.7^{c}	0.0^{d}	2.9^{b}	1.4^{c}
XE1019	0.0	124.3^{a}	111.4^{a}	97.1^{a}	101.4^{a}	62.9^{ab}
Control	0.0	98.6^{a}	52.9^{ab}	90.0^{a}	111.4^{a}	111.4^{a}

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.

Table 16
Mean Seedhead Height of Tall Fescue at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 5 April 1989

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0	0.0	0.0[d1]	38.6[e]	56.9[c]	34.5[c]
Embark	0.0	0.0	28.2[c]	46.3[cd]	65.4[bc]	52.2[bc]
Embark + Escort	0.0	0.0	0.0[d]	0.0[f]	0.0[d]	0.0[d]
Embark + Telar	0.0	0.0	0.0[d]	0.0[f]	0.0[d]	0.0[d]
Manage + Telar	0.0	0.0	30.0[c]	39.1[de]	60.7[bc]	49.6[bc]
Royal Slo-Gro + 2,4-D	0.0	0.0	0.0[d]	44.6[dce]	60.0[bc]	54.7[b]
Shortstop + Banvel	0.0	0.0	0.0[d]	51.6[bc]	59.3[bc]	55.9[b]
XE1019	0.0	0.0	43.1[b]	56.0[b]	67.3[b]	66.1[ab]
Control	0.0	0.0	52.1[a]	66.5[a]	78.6[a]	74.6[a]
BLSD (0.05)	NS	NS	2.72	7.44	8.72	17.66

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 17
Mean Vegetative Height of Kentucky Bluegrass at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 5 April 1989

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	10.0	12.0[c1]	11.2[cd]	17.3[ab]	18.5	20.2
Embark	11.9	14.0[abc]	14.1[ab]	17.9[ab]	14.4	20.2
Embark + Escort	10.4	11.1[c]	13.3[abc]	19.9[a]	20.1	23.2
Embark + Telar	10.3	12.4[bc]	13.2[abc]	18.6[a]	18.8	22.6
Manage + Telar	10.2	11.8[c]	9.0[d]	14.9[b]	15.6	18.5
Royal Slo-Gro + 2,4-D	11.3	14.3[abc]	12.9[bc]	18.5[a]	17.4	18.5
Shortstop + Banvel	11.5	12.6[bc]	10.2[d]	14.9[b]	15.9	18.5
XE1019	13.4	15.9[ab]	15.6[a]	18.4[a]	16.6	19.0
Control	12.4	17.4[a]	14.3[ab]	19.8[a]	20.7	21.0
BLSD (0.05)	NS	3.77	2.43	3.16	NS	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 18
Mean Seedhead Height of Kentucky Bluegrass at Fort Leonard Wood, MO, Following Plant Growth Regulator Application on 5 April 1989

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0	12.4^{bc1}	26.8^{d}	24.3^{b}	33.2^{a}	18.4^{bc}
Embark	0.0	0.0^{d}	26.0^{b}	25.3^{b}	30.3^{a}	27.7^{b}
Embark + Escort	0.0	11.9^{c}	29.4^{b}	26.7^{b}	32.9^{a}	29.9^{b}
Embark + Telar	0.0	12.3^{bc}	27.3^{b}	26.9^{b}	31.0^{a}	27.5^{b}
Manage + Telar	0.0	13.0^{bc}	24.2^{b}	23.4^{b}	31.1^{a}	27.6^{b}
Royal Slo-Gro + 2,4-D	0.0	4.6^{d}	31.1^{b}	34.1^{ab}	37.1^{a}	32.6^{ab}
Shortstop + Banvel	0.0	0.0^{d}	0.0^{c}	9.4^{c}	8.5^{b}	9.2^{c}
XE1019	0.0	17.4^{ab}	31.5^{b}	26.2^{b}	33.2^{a}	29.0^{b}
Control	0.0	20.5^{a}	44.7^{a}	43.9^{a}	43.3^{a}	46.0^{a}
BLSD (0.05)	NS	5.17	10.5	11.7	2.35	15.8

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 19
Plant Growth Regulator Effects on Weed Control at Fort Leonard Wood, MO. Treatment Date = 5 April 1989

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	7.7[a2]	1.3[c]	1.3[c]	1.0[c]	1.0[c]	1.0[b]
Embark	3.3[bc]	1.0[c]	1.0[c]	2.0[c]	2.0[c]	2.0[b]
Embark + Escort	8.3[a]	6.7[a]	6.7[a]	5.7[a]	5.7[a]	5.0[a]
Embark + Telar	7.7[a]	6.3[a]	6.3[a]	3.7[b]	3.7[b]	4.3[a]
Manage + Telar	7.7[a]	5.3[ab]	5.3[ab]	4.0[b]	4.0[b]	4.0[a]
Royal Slo-Gro + 2,4-D	8.3[a]	6.7[a]	6.7[a]	6.7[a]	6.7[a]	4.7[a]
Shortstop + Banvel	6.0[ab]	4.0[b]	4.0[b]	6.0[a]	5.7[a]	4.7[a]
XE1019	6.0[ab]	1.0[c]	1.0[c]	1.0[c]	1.0[c]	2.0[b]
Control	1.0[c]	1.0[c]	1.0[c]	1.0[c]	1.0[c]	1.0[b]
BLSD (0.05)	3.84	1.35	1.35	1.29	1.21	1.56

[1] Weed control was evaluated using a visual scale of 1-9 where 1 = no chemical effect, 5 = minimally acceptable, 9 = excellent, no weeds present.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.

Table 20
Plant Growth Regulator Effects on Turf Color at Fort Leonard Wood, MO. Treatment Date = 5 April 1989

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	8.0^{abc2}	7.7^{ab}	7.0^{ab}	8.0^{a}	8.0	8.0^{a}
Embark	7.7^{bc}	7.7^{ab}	7.3^{ab}	8.0^{a}	8.0	8.0^{a}
Embark + Escort	7.0^{c}	5.0^{c}	5.3^{cd}	7.3^{ab}	7.7	8.0^{a}
Embark + Telar	7.7^{bc}	6.7^{bc}	6.3^{bc}	8.0^{a}	8.0	8.0^{a}
Manage + Telar	7.0^{c}	4.7^{c}	4.3^{d}	6.0^{b}	7.7	8.0^{a}
Royal Slo-Gro + 2,4-D	8.3^{ab}	8.3^{ab}	5.7^{c}	8.0^{a}	8.0	8.0^{a}
Shortstop + Banvel	8.0^{abc}	6.3^{bc}	5.7^{c}	7.3^{ab}	8.0	8.0^{a}
XE1019	9.0^{a}	9.0^{a}	8.0^{a}	7.3^{ab}	7.3	7.3^{b}
Control	9.0^{a}	9.0^{a}	8.0^{a}	7.3^{ab}	8.0	7.0^{c}
BLSD (0.05)	1.25	2.01	1.23	1.41	NS	0.31

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 21
Plant Growth Regulator Effects on Turf Quality at Fort Leonard Wood, MO. Treatment Date = 5 April 1989

Chemical Treatment	Turf Quality (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	8.0^{bc2}	8.0^{a}	7.0^{ab}	5.0^{abc}	3.3	3.0
Embark	7.7^{bc}	7.7^{ab}	7.7^{a}	5.7^{ab}	3.7	3.7
Embark + Escort	7.7^{bc}	6.3^{abc}	6.0^{bc}	6.0^{a}	4.3	3.7
Embark + Telar	7.7^{bc}	7.3^{ab}	6.3^{ab}	5.0^{abc}	4.0	3.7
Manage + Telar	7.3^{c}	4.7^{c}	4.7^{cd}	3.3^{bc}	3.3	3.0
Royal Slo-Gro + 2,4-D	8.3^{ab}	7.3^{ab}	6.7^{ab}	6.3^{a}	4.0	4.0
Shortstop + Banvel	8.0^{bc}	6.3^{abc}	6.0^{bc}	5.0^{abc}	3.3	3.7
XE1019	8.3^{ab}	7.0^{ab}	7.3^{ab}	3.3^{bc}	3.0	3.0
Control	9.0^{a}	6.0^{bc}	4.0^{d}	3.0^{c}	3.0	3.0
BLSD (0.05)	0.90	1.94	1.49	2.37	NS	NS

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf, 5 = minimally acceptable, mowing not yet required, 9 = best quality, optimum greenness, density, and uniformity with excellent vegetative and seedhead suppression and weed control.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 22
Plant Growth Regulator Treatments and Rates of Application at Red River Army Depot, Texarkana, TX. Dates of Application: 13 May 1987; 10 March 1988 (Pre-greenup treatment); 28 April 1988; 8 March 1989 (Pre-greenup treatment); 26 April 1989

Treatment	Rate	
	product/ha	product/acre
Event[1] + X-77 (surfactant)	95.81 ml 0.24 % v:v[2]	8.00 oz 0.25 % v:v
Arsenal	71.83 ml	6.00 oz
Embark + Fusilade	191.55 ml 71.83 ml	1.00 pt 6.00 oz
Embark + Oust	191.50 ml 2.99 ml	1.00 pt 0.25 oz
Oust	11.97 ml	1.00 oz
Oust + Escort	11.97 ml 5.99 ml	1.00 oz 0.50 oz
Roundup + X-77	191.55 ml 0.50 % v:v	16.00 oz 0.50 % v:v
Roundup + Oust	191.55 ml 11.97 ml	16.00 oz 1.00 oz
Roundup + Trooper + X-77	143.66 ml 191.55 ml 0.50 % v:v	12.00 oz 16.00 oz 0.50 % v:v

[1] Formerly experimental use product ACP1911.
[2] Percent volume to volume of the spray mixture.
NOTE: To calculate treatment rate based on active ingredient, use Appendix B.

Table 23
Mean Vegetative Height of Bermudagrass at Red River Army Depot, Texarkana, TX, Following Plant Growth Regulator Application. Treatment Date = 13 May 1987

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	6.4	6.7	--[1]	--	--	--
Arsenal	6.0	6.6	8.6	10.0	--	--
Embark + Fusilade	6.9	--	--	--	--	--
Embark + Oust	7.2	9.2	--	--	--	--
Oust	5.2	7.2	10.9	--	--	--
Oust + Escort	5.4	5.2	8.5	9.6	13.4	--
Roundup	7.0	8.8	--	--	--	--
Roundup + Oust	5.8	5.5	9.5	10.6	11.7	--
Roundup + Trooper	8.5	9.8	--	--	--	--
Control	6.7	6.9	10.2	10.6	10.7	--
BLSD (0.05)	NS	NS	NS	NS	NS	--

[1] Height measurements were not recorded once treatments were assessed unacceptable.
NS = Not significant.

Table 24
Mean Seedhead Height of Bermudagrass at Red River Army Depot, Texarkana, TX, Following Plant Growth Regulator Application on 13 May 1987

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0	0.0	--[1]	--	--	--
Arsenal	0.0	0.0	0.0	4.8[b2]	--	--
Embark + Fusilade	0.0	--	--	--	--	--
Embark + Oust	0.0	7.0	--	--	--	--
Oust	0.0	0.0	22.6	--	--	--
Oust + Escort	0.0	0.0	6.1	15.2[a]	17.6	--
Roundup	0.0	5.2	--	--	--	--
Roundup + Oust	0.0	3.0	4.1	14.6[a]	17.5	--
Roundup + Trooper	0.0	15.0	--	--	--	--
Control	0.0	6.3	15.1	15.4[a]	15.5	--
BLSD (0.05)	NS	NS	NS	8.89	NS	

[1] Height measurements were not recorded once treatments were assessed unacceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 25
Mean Vegetative Height of Bermudagrass at Red River Army Depot Texarkana, TX, Following Plant Growth Regulator Application on 10 March 1988 (pre-greenup treatment date) and 28 April 1988

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	3.8[b1]	5.2	4.9	4.7	5.9	8.8
Arsenal	3.7[b]	4.2	3.9	3.7	4.7	9.7
Embark + Fusilade	4.3[ab]	4.6	4.5	3.7	5.6	8.2
Embark + Oust	4.3[ab]	5.0	5.1	5.3	5.4	7.1
Oust	4.3[ab]	5.0	5.0	4.8	6.0	9.6
Oust + Escort	4.6[ab]	4.8	5.2	4.4	5.7	6.7
Roundup	5.3[a]	5.7	5.8	4.8	6.0	8.8
Roundup + Oust	4.7[ab]	4.8	5.0	5.2	6.0	7.9
Roundup + Trooper	4.6[ab]	5.6	5.8	5.8	6.6	8.6
Control	5.3[a]	5.6	5.8	5.8	5.5	8.0
BLSD (0.05)	1.13	NS	NS	NS	NS	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 26
Effects of Plant Growth Regulator Treatments on Seedhead Number at Red River Army Depot, Texarkana, TX. Treatment Dates = 10 March 1988 (pre-greenup treatment date) and 28 April 1988

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2		
	4 wk	8 wk	12 wk
Event	0.0[a1]	74.6[a]	660.3[a]
Arsenal	125.4[a]	592.0[a]	1376.3[a]
Embark + Fusilade	0.0[a]	35.7[a]	287.3[a]
Embark + Oust	9.6[a]	290.4[a]	601.6[a]
Oust	152.4[a]	663.4[a]	1712.7[a]
Oust + Escort	23.9[a]	149.1[a]	887.3[a]
Roundup	41.3[a]	230.1[a]	798.4[a]
Roundup + Oust	46.0[a]	131.7[a]	1376.3[a]
Roundup + Trooper	50.9[a]	181.0[a]	969.9[a]
Control	106.3[a]	450.9[a]	841.3[a]

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.

Table 27
Mean Seedhead Height of Bermudagrass at Red River Army Depot, Texarkana, TX, Following Plant Growth Regulator Application on 10 March 1988 (pre-greenup treatment date) and 28 April 1988

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0	0.0	3.1	6.8	13.0	12.7
Arsenal	3.4	8.5	10.3	10.7	10.1	12.7
Embark + Fusilade	0.0	0.0	0.0	3.9	12.6	10.9
Embark + Oust	0.0	4.6	4.9	7.9	11.3	11.7
Oust	0.0	12.0	14.1	15.1	18.9	14.8
Oust + Escort	0.0	3.8	6.2	10.2	10.5	11.9
Roundup	0.0	3.9	9.6	9.0	11.8	13.2
Roundup + Oust	0.0	3.4	5.9	10.7	12.4	11.6
Roundup + Trooper	0.0	3.1	9.8	9.9	12.1	13.2
Control	4.7	13.1	14.2	14.0	15.6	14.7
BLSD (0.05)	NS	NS	NS	NS	NS	NS

NS = Not significant.

Table 28
Effects of Plant Growth Regulator Treatments on Turf Color at Red River Army Depot, Texarkana, TX. Treatment Dates = 10 March 1988 (pre-greenup treatment date) and 28 April 1988

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	3.5	5.0	6.3	6.3	4.3	7.0
Arsenal	4.8	8.0	7.3	5.7	5.3	7.0
Embark + Fusilade	4.0	5.3	7.0	4.7	5.3	6.3
Embark + Oust	3.5	7.3	6.3	6.7	5.7	6.7
Oust	2.3	6.3	7.7	7.0	6.7	7.3
Oust + Escort	3.7	6.3	7.7	6.7	6.7	7.0
Roundup	3.8	5.7	7.3	7.7	7.0	7.7
Roundup + Oust	3.7	6.0	7.3	7.7	7.0	7.3
Roundup + Trooper	3.3	5.0	7.3	7.3	7.0	7.0
Control	5.5	8.7	6.7	7.0	6.3	7.0
BLSD (0.05)	NS	NS	NS	NS	NS	NS

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
NS = Not significant.

Table 29
Effects of Plant Growth Regulator Treatments on Weed Control at Red River Army Depot, Texarkana, TX. Treatment Dates = 10 March 1988 (pre-greenup treatment date) and 26 April 1988

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	1.0^{c2}	1.0^{d}	3.0	4.0^{abc}	4.0	2.3^{bc}
Arsenal	4.0^{bc}	4.7^{bcd}	4.7	3.3^{bc}	5.7	3.0^{bc}
Embark + Fusilade	1.0^{c}	2.0^{d}	2.0	3.3^{bc}	4.3	2.3^{bc}
Embark + Oust	4.3^{b}	6.3^{abc}	5.0	5.0^{abc}	5.7	4.7^{ab}
Oust	3.0^{bc}	7.0^{abc}	6.7	4.3^{abc}	5.7	5.7^{ab}
Oust + Escort	7.5^{a}	9.0^{a}	7.0	6.7^{ab}	6.3	6.7^{a}
Roundup	5.7^{ab}	8.3^{ab}	6.7	5.7^{abc}	7.3	6.7^{a}
Roundup + Oust	5.8^{ab}	8.3^{ab}	7.7	7.0^{a}	7.3	7.7^{a}
Roundup + Trooper	5.5^{ab}	8.2^{ab}	6.0	6.7^{ab}	6.7	7.0^{a}
Control	1.0^{c}	3.2^{cd}	2.3	2.7^{c}	4.3	1.0^{c}
BLSD (0.05)	3.04	4.02	NS	3.50	NS	3.51

[1] Weed control was evaluated using a visual scale of 1-9 where 1 = no chemical effect, 5 = minimally acceptable, 9 = excellent, no weeds present.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 30
Effects of Plant Growth Regulator Treatments on Turf Quality at Red River Army Depot, Texarkana, TX. Treatment Dates = 10 March 1988 (pre-greenup treatment date) and 28 April 1988

Chemical Treatment	Turf Quality (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	3.5	3.7	5.0	3.7	3.0	3.7
Arsenal	2.7	4.0	5.0	4.3	4.3	3.3
Embark + Fusilade	2.7	3.0	4.0	3.3	4.0	2.7
Embark + Oust	4.3	6.3	5.7	5.5	4.0	4.7
Oust	4.7	6.0	6.0	5.5	4.0	5.0
Oust + Escort	5.3	6.7	6.7	6.7	5.3	6.0
Roundup	4.8	5.7	6.0	5.5	5.3	5.3
Roundup + Oust	3.7	5.3	6.7	5.7	6.0	5.3
Roundup + Trooper	3.0	5.0	5.7	5.3	4.3	4.3
Control	4.8	4.3	4.7	3.7	4.0	4.3
BLSD (0.05)	NS	NS	NS	NS	NS	NS

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf, 5 = minimally acceptable, mowing not yet required, 9 = best quality, optimum greenness, density, and uniformity with excellent vegetative and seedhead suppression and weed control. NS = Not significant.

Table 31
Mean Vegetative Height of Bermudagrass at Red River Army Depot, Texarkana, TX, Following Plant Growth Regulator Application on 8 March 1989 (pre-greenup treatment date) and 26 April 1989

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	7.2^{ab1}	8.9^{abc}	12.5^{ab}	15.5	22.6	26.7
Arsenal	6.3^{abcd}	10.9^{a}	11.9^{abc}	15.0	24.0	24.0
Embark + Fusilade	7.6^{a}	9.2^{abc}	11.0^{abcd}	14.6	22.1	23.3
Embark + Oust	4.5^{d}	8.2^{bc}	9.5^{abcd}	15.2	22.7	25.5
Oust	5.7^{abcd}	7.3^{c}	6.4^{d}	10.9	15.8	20.0
Oust + Escort	4.8^{cd}	6.9^{c}	8.3^{bcd}	10.5	17.9	19.7
Roundup	6.0^{abcd}	9.6^{abc}	10.6^{abcd}	13.2	20.4	26.0
Roundup + Oust	5.0^{bcd}	7.2^{c}	7.2^{cd}	10.3	19.8	23.8
Roundup + Trooper	7.8^{a}	10.2^{ab}	11.2^{abcd}	14.7	23.1	25.1
Control	6.9^{abc}	10.9^{a}	13.7^{a}	16.5	21.5	28.0
BLSD (0.05)	2.23	2.67	5.11	NS	NS	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 32
Effects of Plant Growth Regulator Treatments on Seedhead Number at Red River Army Depot, Texarkana, TX. Treatment Dates = 8 March 1989 (pre-greenup treatment date) and 26 April 1989

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2		
	4 wk	8 wk	12 wk
Event	0.0[b1]	539.7[a]	--[2]
Arsenal	25.0[b]	669.9[a]	--
Embark + Fusilade	0.0[b]	49.3[a]	--
Embark + Oust	0.0[b]	569.9[a]	--
Oust	0.0[b]	896.9[a]	--
Oust + Escort	0.0[b]	546.0[a]	--
Roundup	9.6[b]	611.1[a]	--
Roundup + Oust	0.0[b]	704.7[a]	--
Roundup + Trooper	4.7[b]	495.3[a]	--
Control	72.6[a]	473.0[a]	--

[1] Means in the same column followed by the same letter are not significantly different at $P = 0.05$ level of the BLSD test.
[2] No viable seedheads were present for measurement at 12 weeks posttreatment.

Table 33
Mean Seedhead Height of Bermudagrass at Red River Army Depot, Texarkana, TX, Following Plant Growth Regulator Application on 8 March 1989 (pre-greenup treatment date) and 26 April 1989

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0	0.0[b1]	6.3	19.9	25.5	29.1
Arsenal	0.0	6.5[b]	11.7	18.3	26.9	25.9
Embark + Fusilade	0.0	0.0[b]	7.0	18.8	24.9	25.3
Embark + Oust	0.0	0.0[b]	7.1	15.6	23.8	22.9
Oust	0.0	0.0[b]	19.2	18.2	21.4	20.9
Oust + Escort	0.0	0.0[b]	9.5	13.7	20.4	20.8
Roundup	0.0	5.5[b]	10.1	15.7	23.3	25.6
Roundup + Oust	0.0	0.0[b]	10.6	13.7	22.1	23.1
Roundup + Trooper	0.0	0.0[b]	14.1	19.9	25.7	24.7
Control	0.0	20.8[a]	18.5	20.8	22.9	26.4
BLSD (0.05)		8.57	NS	NS	NS	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 34
Effects of Plant Growth Regulator Treatments on Turf Color at Red River Army Depot, Texarkana, TX. Treatment Dates = 8 March 1989 (pre-greenup treatment date) and 26 April 1989

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	5.3	6.3[abc2]	6.3	7.7	7.0	8.0
Arsenal	4.3	5.0[cd]	6.0	7.3	7.0	8.0
Embark + Fusilade	4.0	7.0[ab]	6.3	7.7	7.0	8.0
Embark + Oust	4.0	6.3[abc]	6.7	8.0	7.0	8.0
Oust	2.3	3.3[e]	6.7	7.3	7.0	8.0
Oust + Escort	3.7	4.0[de]	7.7	7.3	7.0	8.0
Roundup	5.0	5.7[bc]	7.0	8.0	7.0	8.0
Roundup + Oust	2.5	3.7[de]	8.0	5.3	7.0	8.0
Roundup + Trooper	4.7	6.7[ab]	6.7	6.7	7.0	8.0
Control	4.3	7.7[a]	6.0	6.7	7.0	8.0
BLSD (0.05)	NS	1.62	NS	NS	NS	NS

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 35
Effects of Plant Growth Regulator Treatments on Weed Control at Red River Army Depot, Texarkana, TX. Treatment Dates = 8 March 1989 (pre-greenup treatment date) and 26 April 1989

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	3.7^{cd2}	3.0^{def}	3.7^{cd}	2.0^{cd}	2.7	2.0
Arsenal	3.0^{de}	2.7^{ef}	4.0^{bcd}	2.0^{cd}	3.0	2.0
Embark + Fusilade	2.7^{de}	2.3^{gf}	3.0^{d}	2.3^{cd}	3.0	2.3
Embark + Oust	5.0^{bcd}	4.0^{de}	5.3^{abcd}	2.3^{cd}	2.0	1.7
Oust	5.7^{abc}	6.3^{b}	6.0^{abc}	4.7^{b}	2.7	2.0
Oust + Escort	6.0^{abc}	6.7^{ab}	7.0^{a}	4.7^{b}	3.0	3.3
Roundup	6.0^{abc}	5.7^{bc}	6.3^{ab}	3.3^{bc}	3.3	2.7
Roundup + Oust	8.0^{a}	8.0^{a}	7.7^{a}	7.3^{a}	3.3	3.0
Roundup + Trooper	6.3^{ab}	4.3^{cd}	6.0^{abc}	2.7^{c}	2.7	2.3
Control	1.0^{e}	1.0^{g}	4.3^{bcd}	1.0^{d}	1.7	1.0
BLSD (0.05)	2.37	1.50	2.53	1.36	NS	NS

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 36
Effects of Plant Growth Regulator Treatments on Turf Quality at Red River Army Depot, Texarkana, TX. Treatment Dates = 8 March 1989 (pre-greenup treatment date) and 26 April 1989

Chemical Treatment	Turf Quality (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	3.0	2.7^{b2}	4.3^{cd}	2.0^{c}	3.3	2.0^{b}
Arsenal	3.3	2.7^{b}	3.0^{d}	2.7^{bc}	3.3	2.3^{ab}
Embark + Fusilade	3.0	2.7^{b}	3.0^{d}	2.3^{bc}	3.0	2.3^{ab}
Embark + Oust	3.0	4.7^{a}	5.3^{bcd}	2.0^{c}	3.0	2.0^{b}
Oust	2.3	6.3^{a}	6.3^{abc}	2.3^{bc}	3.7	2.0^{b}
Oust + Escort	4.3	6.0^{a}	8.0^{a}	4.0^{ab}	4.0	2.7^{ab}
Roundup	5.0	6.3^{a}	5.7^{abc}	3.3^{bc}	4.0	2.3^{ab}
Roundup + Oust	3.0	6.3^{a}	7.3^{ab}	5.3^{a}	3.7	3.0^{a}
Roundup + Trooper	4.0	5.0^{a}	5.7^{abc}	2.3^{bc}	3.3	2.0^{b}
Control	3.0	2.7^{b}	4.3^{cd}	2.0^{c}	2.7	2.0^{b}
BLSD (0.05)	NS	1.80	2.59	1.74	NS	0.73

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf, 5 = minimally acceptable, mowing not yet required, 9 = best quality, optimum greenness, density, and uniformity with excellent vegetative and seedhead suppression and weed control.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 37
Plant Growth Regulator Treatments and Rates of Application at Charleston Naval Weapons Station, Charleston, SC. Dates of Application = 16 April 1987; 24 May 1988; 19 May 1989

Treatment	Rate	
	product/ha	product/acre
Event[1] + X-77 (surfactant)	95.8 ml 0.25 % v:v[2]	8.00 oz 0.25 % v:v
Embark + Fusilade	191.55 ml 71.83 ml	1.00 pt 6.00 oz
Embark + Oust	191.55 ml 2.99 ml	1.00 pt 0.25 oz
Royal Slo-Gro	3.56 L 7.13 L	2.00 gal (1987) 4.00 gal (1988)[3]
Telar	5.99 ml	0.50 oz
Oust	5.99 ml	0.50 oz

[1] Formerly experimental use product ACP1911.
[2] Percent volume to volume of the spray mixture.
[3] New product label rate imposed in 1988.
NOTE: To calculate treatment rate based on active ingredient, use Appendix B.

Table 38
Mean Vegetative Height of Bahiagrass at Charleston Naval Weapons Station, Charleston, SC, Following Plant Growth Regulator Application on 16 April 1987

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	12.6[b1]	14.4[b]	23.3[abc]	33.3[ab]	52.2	48.3
Embark + Fusilade	17.3[a]	19.8[a]	29.0[a]	33.4[ab]	50.8	43.6
Embark + Oust	12.6[b]	12.8[b]	20.8[bc]	29.0[bc]	43.7	41.8
Royal Slo-Gro	17.0[a]	22.8[a]	27.3[ab]	37.2[a]	50.8	43.4
Telar	13.5[ab]	15.4[b]	26.4[ab]	37.2[a]	51.2	46.2
Oust	14.8[ab]	13.8[b]	16.8[c]	25.6[c]	37.3	38.9
Control	17.2[a]	22.6[a]	27.8[ab]	34.9[ab]	51.2	45.0
BLSD (0.05)	4.10	4.00	8.05	7.23	NS	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 39
Mean Seedhead Height of Bahiagrass at Charleston Naval Weapons Station, Charleston, SC, Following Plant Growth Regulator Application on 16 April 1987

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk[1]	4 wk[1]	6 wk	8 wk	10 wk	12 wk
Event	--	--	0.0[c,2]	57.6[d]	82.1[a]	91.1
Embark + Fusilade	--	--	44.2[b]	73.7[b]	84.8[a]	88.3
Embark + Oust	--	--	0.0[c]	0.0[e]	66.0[b]	81.0
Royal Slo-Gro	--	--	48.1[ab]	73.6[b]	83.9[a]	81.7
Telar	--	--	39.8[b]	67.7[c]	84.8[a]	83.9
Oust	--	--	0.0[c]	0.0[e]	70.5[b]	78.9
Control	--	--	54.8[a]	81.0[a]	84.7[a]	85.1
BLSD (0.05)	--	--	9.53	5.16	11.36	NS

[1] Seedheads had not yet emerged for measurement.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 40
Mean Vegetative Height of Bahiagrass at Charleston Naval Weapons Station, Charleston, SC, Following Plant Growth Regulator Application on 24 May 1988

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	21.9	21.1[a]	28.0	32.2[a]	44.8	44.4
Embark + Fusilade	22.8	21.2[bc]	31.2	31.1[a]	43.7	42.7
Embark + Oust	20.5	21.7[bc]	22.1	26.4[ab]	40.1	46.9
Royal Slo-Gro	24.1	25.0[b]	23.9	23.2[b]	37.0	43.3
Telar	24.9	24.3[bc]	27.5	31.1[a]	46.4	49.0
Oust	21.7	21.1[c]	22.7	24.6[b]	35.8	42.3
Control	27.1	31.7[a]	29.3	32.0[a]	39.3	45.2
BLSD (0.05)	NS	3.82	NS	6.48	NS	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 41
Mean Seedhead Height of Bahiagrass at Charleston Naval Weapons Station, Charleston, SC, Following Plant Growth Regulator Application on 24 May 1988

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	0.0[d1]	0.0[d]	43.3[bcd]	41.3[bc]	67.4[ab]	80.6
Embark + Fusilade	0.0[d]	0.0[d]	53.2[abc]	4o.5[b]	68.7[ab]	79.1
Embark + Oust	0.0[d]	23.9[c]	50.2[abc]	45.6[b]	59.9[bc]	73.0
Royal Slo-Gro	39.8[b]	44.2[b]	29.6[d]	36.5[c]	56.0[c]	75.7
Telar	27.9[c]	41.7[b]	60.5[ab]	57.6[a]	71.7[a]	75.1
Oust	0.0[d]	0.0[d]	39.2[cd]	37.7[c]	44.5[d]	74.8
Control	49.8[a]	62.8[a]	66.1[a]	62.0[a]	69.5[ab]	75.9
BLSD (0.05)	3.81	13.89	19.84	6.71	10.28	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 42
Plant Growth Regulator Effects on Bahiagrass Seedhead Number at Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 24 May 1988

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2		
	4 wk	8 wk	12 wk
Event	1.1[d][1]	51.4[ab]	64.3
Embark + Fusilade	2.9[d]	25.7[bc]	81.4
Embark + Oust	17.1[c]	58.6[ab]	54.3
Royal Slo-Gro	7.1[cd]	2.9[c]	54.3
Telar	41.4[b]	98.6[a]	90.0
Oust	2.9[d]	12.9[c]	41.4
Control	75.7[a]	162.9[a]	130.0

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.

Table 43
Plant Growth Regulator Effects on Turf Color at the Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 24 May 1988

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	7.7[a2]	6.7[bc]	7.0	7.0[ab]	6.7	6.7
Embark + Fusilade	4.7[b]	5.3[d]	7.0	7.7[a]	7.3	7.0
Embark + Oust	7.0[a]	6.0[cd]	6.7	7.3[a]	7.0	7.0
Royal Slo-Gro	6.3[ab]	7.3[ab]	7.3	6.3[b]	7.7	7.7
Telar	7.3[a]	6.7[bc]	7.3	7.0[ab]	7.0	7.0
Oust	7.0[a]	6.3[bcd]	6.0	7.0[ab]	7.7	7.3
Control	7.3[a]	8.0[a]	7.3	7.0[ab]	7.3	6.7
BLSD (0.05)	1.72	1.10	NS	0.74	NS	NS

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 44
Plant Growth Regulator Effects on Weed Control at the Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 24 May 1988

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	8.0[a2]	1.3[b]	1.7[b]	1.0[b]	1.7[ab]	1.2
Embark + Fusilade	5.7[a]	1.0[b]	1.7[b]	1.7[ab]	4.3[a]	1.5
Embark + Oust	6.7[a]	1.0[b]	1.0[b]	2.2[a]	2.7[ab]	1.7
Royal Slo-Gro	7.0[a]	2.3[a]	5.3[a]	1.0[b]	4.7[a]	2.3
Telar	7.0[a]	1.7[ab]	1.3[b]	1.3[ab]	4.3[a]	1.7
Oust	7.0[a]	1.7[ab]	1.0[b]	2.0[ab]	4.7[a]	1.7
Control	2.7[b]	1.0[b]	1.0[b]	1.0[b]	1.0[b]	1.0
BLSD (0.05)	2.63	0.83	2.23	1.00	3.25	NS

[1] Weed control was evaluated using a visual scale of 1-9 where 1 = no chemical effect, 5 = minimally acceptable, 9 = excellent, no weeds present.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 45
Plant Growth Regulator Effects on Turf Quality at the Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 24 May 1988

Chemical Treatment	Turf Quality (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	7.7	7.0^{ab2}	5.3^{abc}	5.0^{bc}	4.0^{c}	3.7
Embark + Fusilade	6.0	6.3^{ab}	4.7^{bc}	5.3^{b}	5.0^{bc}	3.5
Embark + Oust	6.7	6.3^{ab}	4.7^{bc}	5.3^{b}	4.7^{bc}	3.5
Royal Slo-Gro	6.0	6.7^{ab}	7.3^{a}	7.5^{a}	6.3^{ab}	4.0
Telar	7.0	5.7^{bc}	4.0^{bc}	3.3^{c}	4.0^{c}	3.7
Oust	7.3	7.3^{a}	6.0^{ab}	6.3^{ab}	7.3^{a}	3.2
Control	5.7	4.3^{c}	3.3^{c}	3.3^{c}	3.7^{c}	4.0
BLSD (0.05)	NS	1.59	2.25	1.75	2.17	NS

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf, 5 = minimally acceptable, mowing not yet required, 9 = best quality, optimum greenness, density and uniformity with excellent vegetative and seedhead suppression and weed control.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
NS = Not significant.

Table 46
Mean Vegetative Height of Bahiagrass at Charleston Naval Weapons Station, Charleston, SC, Following Plant Growth Regulator Application on 19 May 1989

Chemical Treatment	Vegetative Height (Weeks Posttreatment)					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	17.9[c1]	21.1[c]	39.2[a]	42.0	..[2]	..
Embark + Fusilade	25.4[ab]	26.3[ab]	41.4[a]	43.5	..	..
Embark + Oust	19.6[bc]	20.2[c]	37.0[ab]	37.8	..	..
Royal Slo-Gro	19.8[bc]	22.1[bc]	38.4[a]	40.6	..	..
Telar	15.5[c]	20.7[c]	39.4[a]	42.3	..	..
Oust	15.4[c]	16.9[c]	32.6[b]	33.5	..	..
Control	27.0[a]	27.6[a]	40.3[a]	42.5	..	..
BLSD (0.05)	5.93	5.16	5.06	NS	..	..

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] All plots were inadvertently mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.
NS = Not significant.

Table 47
Mean Seedhead Height of Bahiagrass at Charleston Naval Weapons Station, Charleston, SC, Following Plant Growth Regulator Application on 19 May 1989

Chemical Treatment	Seedhead Height (Weeks Posttreatment)					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	..[1]	0.0[c2]	70.8	75.2[ab]	..[3]	..
Embark + Fusilade	--	48.0[b]	76.3	81.8[a]	--	--
Embark + Oust	--	0.0[c]	72.2	73.1[abc]	--	--
Royal Slo-Gro	--	0.0[c]	71.1	76.1[ab]	--	--
Telar	--	0.0[c]	70.2	67.1[bc]	--	--
Oust	--	0.0[c]	62.4	63.2[c]	--	--
Control	--	54.1[a]	75.1	82.8[a]	--	--
BLSD (0.05)	--	4.42	NS	10.47	--	--

[1] Seedheads had not yet emerged for measurement.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[3] All plots were inadvertently mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.
NS = Not significant.

Table 48
Plant Growth Regulator Effects on Bahiagrass Seedhead Number at Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 19 May 1989

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2		
	4 wk	8 wk	12 wk
Event	0.0	57.1[c1]	--[2]
Embark + Fusilade	11.4	127 1[ab]	--
Embark + Oust	0.0	97.1[abc]	--
Royal Slo-Gro	1.4	67.1[bc]	--
Telar	4.3	64.3[bc]	--
Oust	2.9	20.0[d]	--
Control	5.7	152.9[a]	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] All plots were inadvertently mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.

Table 49
Plant Growth Regulator Effects on Turf Color at the Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 19 May 1989

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	7.0[b2]	8.0[b]	8.0	9.0	..[3]	..
Embark + Fusilade	7.7[a]	9.0[a]	8.3	9.0	..	..
Embark + Oust	7.0[b]	8.0[b]	8.0	9.0	..	..
Royal Slo-Gro	8.0[a]	8.0[b]	8.3	9.0	..	..
Telar	6.7[b]	7.7[b]	8.0	9.0	..	..
Oust	7.0[b]	6.3[c]	8.3	9.0	..	..
Control	8.0[a]	9.0[a]	8.3	9.0	..	..
BLSD (0.05)	0.53	0.50	NS	NS	..	..

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at $P = 0.05$ level of the BLSD test.
[3] All plots were inadvertently mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.
NS = Not significant.

Table 50
Plant Growth Regulator Effects on Weed Control at the Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 19 May 1989

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	7.7	1.0[c2]	4.0[a]	2.3	..[3]	..
Embark + Fusilade	7.7	1.0[c]	4.3[a]	1.0	..	..
Embark + Oust	7.7	2.7[a]	4.0[a]	3.0	..	..
Royal Slo-Gro	8.0	1.7[bc]	4.0[a]	4.0	..	..
Telar	7.7	1.7[bc]	4.3[a]	1.3	..	..
Oust	8.0	2.3[ab]	4.3[a]	2.7	..	..
Control	5.7	1.0[c]	1.0[b]	1.0	..	..
BLSD (0.05)	NS	0.76	1.69	NS	..	..

[1] Weed control was evaluated using a visual scale of 1-9 where 1 = no chemical effect, 5 = minimally acceptable, 9 = excellent, no weeds present.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[3] All plots were inadvertently mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.
NS = Not significant.

Table 51
Plant Growth Regulator Effects on Turf Quality at the Charleston Naval Weapons Station, Charleston, SC. Treatment Date = 19 May 1989

Chemical Treatment	*Turf Quality (Weeks Posttreatment)*[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event	7.3	7.7	4.0	3.0	..[2]	..
Embark + Fusilade	7.0	6.0	4.0	3.0	..	..
Embark + Oust	7.7	7.3	4.0	3.3	..	..
Royal Slo-Gro	7.7	7.3	4.0	3.3	..	..
Telar	7.7	7.0	4.0	3.0	..	..
Oust	7.7	6.3	4.0	4.0	..	..
Control	8.0	7.0	4.0	3.0	..	..
BLSD (0.05)	NS	NS	NS	NS	..	..

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf, 5 = minimally acceptable, mowing not yet required, 9 = best quality, optimum greenness, density, and uniformity with excellent vegetative and seedhead suppression and weed control.
[2] All plots were inadvertently mowed after the 8-week posttreatment evaluation; therefore, no measurements were recorded after this point.
NS = Not significant.

Table 52
Plant Growth Regulator Treatments and Rates of Application at Willow Grove Naval Air Station, Willow Grove, PA. Dates of Application: 29 April 1987, 22 April 1988, 19 April 1989

Treatment	Rate	
	product/ha	product/acre
Event[1] +	95.81 ml	8.00 oz
2,4-D +	766.19 ml	64.00 oz
X-77 (surfactant)	0.25 % v:v[2]	0.25 % v:v
Embark +	5.99 ml	0.50 pt
Escort	2.99 ml	0.25 oz
Escort +	3.99 ml	0.33 oz
Manage	47.89 ml	4.00 oz
Limit +	1.10 kg	6.01 lb
2,4-D +	0.39 kg	2.14 lb
Banvel	0.92 kg	5.00 lb
MON 4625 +	0.88 kg	4.81 lb
2,4-D +	0.39 kg	2.14 lb
Banvel	0.92 kg	5.00 lb
Royal Slo-Gro +	3.56 L	2.00 gal (1987)
	7.13 L	4.00 gal (1988)[3]
2,4-D	0.38 L	1.00 qt
Shortstop +	14.70 kg	80.00 lb
Banvel	1.84 kg	10.00 lb
Telar +	5.99 ml	0.50 oz
Manage	47.89 ml	4.00 oz

[1] Formerly experimental use product ACP1911.
[2] Percent volume to volume of the spray mixture.
[3] New product label rate imposed in 1988.
NOTE: To calculate treatment rate based on active ingredient, use Appendix B.

Table 53
Mean Vegetative Height of Tall Fescue at Willow Grove Naval Air Station Willow Grove, PA, Following Plant Growth Regulator Application on 29 April 1987

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	--	22.2[b1]	--[2]	--	--	--
Embark + Escort	--	16.8[c]	17.8[b]	28.8[b]	--	32.8
Escort + Manage	--	17.0[c]	19.0[b]	33.8[a]	--	--
Limit + Banvel + 2,4-D	--	--	--	--	--	--
MON4625 + 2,4-D + Banvel	--	21.5[b]	23.1[b]	29.1[b]	--	32.2
Royal Slo-Gro + 2,4-D	--	--	--	--	--	--
Shortstop + Banvel	--	--	--	--	--	--
Telar + Manage	--	16.4[c]	18.7[b]	28.9[b]	--	--
Control	--	30.0[a]	35.5[a]	45.4[a]	--	39.8
BLSD (0.05)	--	1.84	7.99	11.20	--	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] Height measurements were not recorded once treatments were assessed unacceptable. In addition, no evaluations were performed at 2 and 10 weeks posttreatment.
NS = Not significant.

Table 54
Mean Seedhead Height of Tall Fescue at Willow Grove Naval Air Station Willow Grove, PA, Following Plant Growth Regulator Application on 29 April 1987

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	--	20.9[bc1]	--[2]	--	--	--
Embark + Escort	--	7.1[c]	7.7[b]	25.8[c]	--	--
Escort + Manage	--	8.9[c]	9.7[b]	57.9[b]	--	--
Limit + Banvel + 2,4-D	--	--	--	--	--	--
MON4625 + 2,4-D + Banvel	--	38.6[b]	41.2[ab]	46.4[bc]	--	--
Royal Slo-Gro + 2,4-D	--	--	--	--	--	--
Shortstop + Banvel	--	--	--	--	--	--
Telar + Manage	--	15.9[bc]	18.0[b]	51.3[b]	--	--
Control	--	66.8[a]	68.9[a]	93.2[a]	--	--
BLSD (0.05)	--	27.98	34.44	23.97	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] Height measurements were not recorded once treatments were assessed unacceptable. In addition, no evaluations were performed at 2 and 10 weeks posttreatment.

Table 56
Mean Seedhead Height of Kentucky Bluegrass at Willow Grove Naval Air Station Willow Grove, PA, Following Plant Growth Regulator Application on 29 April 1987

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	--	34.8[b1]	--[2]	--	--	--
Embark + Escort	--	18.9[c]	19.5[b]	24.4[b]	--	--
Escort + Manage	--	21.5[c]	22.1[b]	26.8[b]	--	--
Limit + Banvel + 2,4-D	--	--	--	--	--	--
MON4625 + 2,4-D + Banvel	--	18.8[b]	22.7[b]	25.6[b]	--	--
Royal Slo-Gro + 2,4-D	--	--	--	--	--	--
Shortstop + Banvel	--	--	--	--	--	--
Telar + Manage	--	25.0[c]	25.0[b]	28.7[b]	--	--
Control	--	51.6[a]	56.1[a]	55.0[a]	--	--
BLSD (0.05)	--	7.33	13.77	7.82	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] Height measurements were not recorded once treatments were assessed unacceptable. In addition, no evaluations were performed at 2 and 10 weeks posttreatment, and no viable seedheads were present for measurement at 12 weeks posttreatment.

Table 55
Mean Vegetative Height of Kentucky Bluegrass at Willow Grove Naval Air Station Willow Grove, PA, Following Plant Growth Regulator Application on 29 April 1987

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	--	17.8[b1]	--[2]	--	--	--
Embark + Escort	--	14.4[b]	15.7[b]	29.1[b]	--	31.6
Escort + Manage	--	15.0[b]	15.9[b]	27.7[bc]	--	--
Limit + Banvel + 2,4-D	--	--	--	--	--	--
MON4625 + 2,4-D + Banvel	--	15.5[b]	16.5[ab]	18.4[c]	--	25.8
Royal Slo-Gro + 2,4-D	--	--	--	--		--
Shortstop + Banvel	--	--	--	--	--	--
Telar + Manage	--	15.8[b]	16.9[ab]	22.5[bc]	-	--
Control	--	23.0[a]	25.[a]	39.7[a]	--	36.9
BLSD (0.05)	--	4.16	9.29	10.16	-	NS

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] Height measurements were not recorded once treatments were assessed unacceptable. In addition, no evaluations were performed at 2 and 12 weeks posttreatment.
NS = Not significant.

Table 57
Mean Vegetative Height of Tall Fescue at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 22 April 1988

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	15.7^{bc1}	16.4^{cd}	27.1^{b}	27.3^{bc}	--[2]	31.7^{ab}
Embark + Escort	10.1^{e}	11.8^{e}	24.7^{b}	22.8^{d}	--	23.9^{e}
Escort + Manage	12.2^{de}	15.5^{cde}	28.8^{b}	24.4^{cd}	--	27.7^{c}
Limit + Banvel + 2,4-D	14.8^{ca}	16.9^{cd}	26.2^{b}	27.7^{bc}	--	28.9^{bc}
MON4625 + 2,4-D + Banvel	16.0^{bc}	16.5^{cd}	25.8^{b}	25.8^{cd}	--	27.4^{c}
Royal Slo-Gro + 2,4-D	16.6^{bc}	18.3^{bc}	28.3^{b}	27.9^{bc}	--	27.2^{cd}
Shortstop + Banvel	17.6^{b}	22.2^{b}	24.9^{b}	30.1^{ab}	--	29.2^{bc}
Telar + Manage	12.7^{de}	13.8^{de}	26.5^{b}	23.1^{d}	--	24.1^{de}
Control	21.4^{a}	28.8^{a}	46.1^{a}	32.8^{a}	--	32.5^{a}
BLSD (0.05)	2.82	4.08	5.17	4.09	--	3.24

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] No evaluations were performed at 10 weeks posttreatment.

Table 58
Plant Growth Regulator Effects on Seedhead Number at the Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 22 April 1988

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2					
	Tall Fescue			Kentucky Bluegrass		
	4 wk	8 wk	12 wk	4 wk	8 wk	12 wk
Event + 2,4-D	0.0[c1]	84.3[ab]	--[2]	7.1[a]	--[2]	--
Embark + Escort	0.0[c]	11.4[c]	--	11.4[b]	--	--
Embark + Manage	14.3[b]	88.6[b]	--	22.9[b]	--	--
Limit + Banvel + 2,4-D	0.0[c]	14.3[c]	--	100.0[a]	--	--
MON4625 + 2,4-D + Banvel	0.0[c]	17.1[c]	--	15.7[b]	--	--
Royal Slo-Gro + 2,4-D	0.0[c]	10.0[c]	--	67.1[a]	--	--
Shortstop + Banvel	48.6[a]	97.1[ab]	--	5.7[b]	--	--
Telar + Manage	0.0[c]	80.0[b]	--	70.0[a]	--	--
Control	78.6[a]	131.4[a]	--	65.7[a]	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] No viable seedheads were present for measurement at 8 and 12 weeks posttreatment for Kentucky bluegrass and 12 weeks posttreatment for tall fescue.

Table 59
Mean Seedhead Height of Tall Fescue at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 22 April 1988

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	0.0[b1]	0.0[d]	59.2	56.3[bc]	--[2]	--
Embark + Escort	0.0[b]	0.0[d]	33.0	31.9[d]	--	--
Escort + Manage	0.0[b]	8.0[c]	56.6	61.8[bc]	--	--
Limit + Banvel + 2,4-D	0.0[b]	0.0[d]	48.6	58.9[bc]	--	--
MON4625 + 2,4-D + Banvel	0.0[b]	0.0[d]	38.6	66.8[bc]	--	--
Royal Slo-Gro + 2,4-D	0.0[b]	0.0[d]	45.0	58.4[bc]	--	--
Shortstop + Banvel	0.0[b]	24.5[b]	64.1	74.6[ab]	--	--
Telar + Manage	0.0[b]	0.0[d]	45.7	54.2[c]	--	--
Control	29.7[a]	33.7[a]	71.5	88.1[a]	--	--
BLSD (0.05)	0.25	7.82	NS	19.55	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] No evaluations were performed at 10 weeks posttreatment. In addition, no viable seedheads were present for measurement at 12 weeks posttreatment.
NS = Not significant.

Table 60
Mean Vegetative Height of Bluegrass at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 22 April 1988

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	11.9^{bc1}	15.6^{bc}	20.5^{b}	21.5^{b}	--[2]	23.1^{abc}
Embark + Escort	8.8^{d}	12.2^{d}	18.0^{b}	20.7^{b}	--	21.5^{bc}
Escort + Manage	9.1^{d}	13.8^{bcd}	20.7^{b}	20.5^{b}	--	22.1^{abc}
Limit + Banvel + 2,4-D	10.5^{cd}	12.6^{d}	17.7^{b}	20.4^{b}	--	21.0^{bc}
MON4625 +2,4-D + Banvel	12.4^{bc}	12.4^{d}	16.2^{b}	17.6^{b}	--	21.6^{bc}
Royal Slo-Gro + 2,4-D	12.9^{bc}	13.2^{bcd}	18.7^{b}	21.3^{b}	--	23.6^{ab}
Shortstop + Banvel	12.9^{b}	16.0^{b}	18.6^{b}	21.8^{b}	--	22.4^{abc}
Telar + Manage	10.8^{bcd}	13.1^{cd}	20.0^{b}	20.0^{b}	--	19.4^{c}
Control	17.4^{a}	23.0^{a}	45.5^{a}	28.2^{a}	--	25.9^{a}
BLSD (0.05)	2.37	2.89	4.85	4.43	--	4.17

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] No evaluations were performed at 10 weeks posttreatment.

Table 61
Mean Seedhead Height of Kentucky Bluegrass at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 22 April 1988

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	0.0[b1]	17.0[b]	--[2]	--	--	--
Embark + Escort	0.0[b]	0.0[e]	--	--	--	--
Escort + Manage	0.0[b]	12.5[c]	--	--	--	--
Limit + Banvel + 2,4-D	0.0[b]	8.9[cd]	--	--	--	--
MON4625 + 2,4-D + Banvel	0.0[b]	0.0[e]	--	--	--	--
Royal Slo-Gro + 2,4-D	0.0[b]	18.3[b]	--	--	--	--
Shortstop + Banvel	0.0[b]	0.0[e]	--	--	--	--
Telar + Manage	0.0[b]	14.2[c]	--	--	--	--
Control	17.6[a]	26.6[a]	--	--	--	--
BLSD (0.05)	0.29	2.56				

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] Bluegrass seedhead heights were not measured at 6 weeks posttreatment, and by the next evaluation, no viable seedheads were present for measurement.

Table 62
Effects of Plant Growth Regulator Treatments on Turf Color at Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 22 April 1988

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	4.3^{bc2}	6.8^{b}	6.7	7.3	..[3]	2.7^{ab}
Embark + Escort	3.0^{d}	5.3^{cd}	7.7	6.3	..	3.0^{ab}
Escort + Manage	3.7^{cd}	4.0^{e}	5.3	6.3	..	2.7^{ab}
Limit + Banvel + 2,4-D	4.7^{ab}	6.3^{bc}	7.0	7.7	..	3.7^{a}
MON4625 + 2,4-D + Banvel	3.7^{cd}	7.3^{b}	7.0	7.3	..	2.7^{ab}
Royal Slo-Gro + 2,4-D	5.0^{ab}	6.7^{b}	5.0	7.7	..	3.7^{a}
Shortstop + Banvel	4.7^{ab}	7.3^{b}	5.7	6.7	..	2.3^{b}
Telar + Manage	3.7^{cd}	4.3^{de}	5.0	6.7	..	3.0^{ab}
Control	5.3^{a}	9.0^{a}	6.3	8.0	..	2.0^{b}
BLSD (0.05)	0.87	1.08	NS	NS	..	1.15

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[3] No evaluations were performed at 10 weeks posttreatment.
NS = not significant.

Table 63
Effects of Plant Growth Regulator Treatments on Weed Control at Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 22 April 1988

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	5.0^{ab2}	5.0^{b}	6.7^{a}	4.7^{ab}	..[3]	5.0^{ab}
Embark + Escort	8.3^{a}	6.7^{a}	7.0^{a}	5.3^{a}	..	4.0^{bc}
Escort + Manage	6.0^{ab}	5.3^{b}	5.7^{ab}	4.7^{ab}	..	4.0^{bc}
Limit + Banvel + 2,4-D	5.3^{ab}	5.7^{ab}	6.3^{a}	5.8^{a}	..	6.0^{a}
MON4625 + 2,4-D + Banvel	6.0^{ab}	5.0^{b}	5.0^{ab}	5.0^{a}	..	6.3^{a}
Royal Slo-Gro + 2,4-D	4.0^{bc}	2.3^{d}	4.7^{b}	3.0^{bc}	..	2.7^{cd}
Shortstop + Banvel	4.0^{bc}	2.0^{de}	6.3^{a}	2.3^{cd}	..	1.7^{d}
Telar + Manage	5.0^{ab}	3.7^{c}	6.3^{a}	4.0^{abc}	..	2.7^{cd}
Control	1.0^{c}	1.0^{e}	1.0^{c}	1.0^{d}	..	1.0^{d}
BLSD (0.05)	3.35	1.26	1.64	1.90	..	1.87

[1] Weed control was evaluated using a visual scale of 1-9 where 1 = no chemical effect, 5 = minimally acceptable, 9 = excellent, no weeds present.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[3] No evaluations were performed at 10 weeks posttreatment.

Table 64
Effects of Plant Growth Regulator Treatments on Turf Quality at Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 22 April 1988

Chemical Treatment	Turf Quality (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	4.7	6.7[a2]	6.3[ab]	3.7[cd]	..[3]	3.3[ab]
Embark + Escort	5.3	6.2[ab]	7.0[a]	6.3[a]	..	3.3[ab]
Escort + Manage	4.7	5.3[b]	4.0[d]	3.5[cd]	..	3.3[ab]
Limit + Banvel + 2,4-D	3.7	7.0[a]	7.0[a]	5.3[ab]	..	3.7[ab]
MON4625 + 2,4-D + Banvel	5.7	7.0[a]	6.0[abc]	5.3[ab]	..	4.0[a]
Royal Slo-Gro + 2,4-D	5.7	5.3[b]	5.0[bcd]	4.3[bc]	..	3.7[ab]
Shortstop + Banvel	5.3	5.3[b]	4.3[cd]	2.7[d]	..	2.3[cd]
Telar + Manage	5.7	5.3[b]	5.0[bcd]	3.3[cd]	..	3.0[bc]
Control	5.3	4.0[c]	1.0[e]	3.3[cd]	..	2.0[d]
BLSD (0.05)	NS	1.18	1.80	1.52	..	0.82

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf, 5 = minimally acceptable, mowing not yet required, 9 = best quality, optimum greenness, density, and uniformity with excellent vegetative and seedhead suppression and weed control.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[3] No evaluations were performed at 10 weeks posttreatment.
NS = not significant.

Table 65
Mean Vegetative Height of Tall Fescue at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 19 April 1989

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	13.4[bc,1]	14.7[d]	--[2]	25.0[abc]	--	--
Embark + Escort	13.1[bc]	11.9[e]	--	21.6[bc]	--	--
Escort + Manage	16.7[abc]	14.2[de]	--	22.3[bc]	--	--
Limit + Banvel + 2,4-D	18.9[ab]	23.5[a]	--	26.8[ab]	--	--
MON4625 + 2,4-D + Banvel	21.5[a]	21.6[ab]	--	23.9[abc]	--	--
Royal Slo-Gro + 2,4-D	15.2[abc]	18.4[c]	--	24.7[abc]	--	--
Shortstop + Banvel	19.4[ab]	20.9[bc]	--	26.2[ab]	--	--
Telar + Manage	11.3[c]	14.8[d]	--	19.9[c]	--	--
Control	19.7[ab]	22.5[ab]	--	28.6[a]	--	--
BLSD (0.05)	6.82	2.62	--	5.61	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] No evaluations were performed at 6 weeks posttreatment. In addition, destruction of the test area by mowing equipment prematurely terminated this experiment at 9 weeks posttreatment.

Table 66
Mean Seedhead Height of Tall Fescue at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 19 April 1989

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	0.0	0.0[c][1]	--[2]	46.8[cd]	--	--
Embark + Escort	0.0	0.0[c]	--	43.3[d]	--	--
Escort + Manage	0.0	0.0[c]	--	46.4[cd]	--	--
Limit + Banvel + 2,4-D	6.5	23.4[b]	--	59.1[b]	--	--
MON4625 + 2,4-D + Banvel	0.0	24.1[b]	--	53.9[b]	--	--
Royal Slo-Gro + 2,4-D	0.0	0.0[c]	--	53.0[bc]	--	--
Shortstop + Banvel	0.0	24.7[b]	--	55.5[b]	--	--
Telar + Manage	0.0	0.0[c]	--	45.1[d]	--	--
Control	9.1	27.9[a]	--	69.0[a]	--	--
BLSD (0.05)	NS	2.61	--	6.61	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] No evaluations were performed at 6 weeks posttreatment. In addition, destruction of the test area by mowing equipment prematurely terminated this experiment at 9 weeks posttreatment.

Table 67
Plant Growth Regulator Effects on Seedhead Number at the Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 19 April 1989

Chemical Treatment	Seedhead Number (Weeks Posttreatment), Seedheads/m^2					
	Tall Fescue			Kentucky Bluegrass		
	4 wk	8 wk	12 wk	4 wk	8 wk	12 wk
Event + 2,4-D	0.0^{d1}	32.9^{bc}	--[2]	67.1	47.1^{abc}	--[2]
Embark + Escort	0.0^{d}	10.0^{d}	--	41.4	35.7^{abc}	--
Embark + Manage	0.0^{d}	22.9^{cd}	--	35.7	27.1^{bc}	--
Limit + Banvel + 2,4-D	25.7^{ab}	82.9^{a}	--	47.1	64.3^{ab}	--
MON4625 + 2,4-D + Banvel	32.9^{a}	68.6^{ab}	--	82.9	74.3^{ab}	--
Royal Slo-Gro + 2,4-D	0.0^{d}	34.3^{bcd}	--	68.6	30.0^{abc}	--
Shortstop + Banvel	18.6^{b}	87.1^{a}	--	25.7	14.3^{c}	--
Telar + Manage	0.0^{d}	54.3^{abc}	--	82.9	87.1^{a}	--
Control	7.1^{c}	58.6^{ab}	--	94.3	61.4^{abc}	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the BLSD test.
[2] No seedheads were counted at 12 weeks posttreatment due to destruction of the test area by mowing equipment.

Table 68
Mean Vegetative Height of Kentucky Bluegrass at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 19 April 1989

Chemical Treatment	Vegetative Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	13.0	15.1[abc1]	--[2]	19.7	--	--
Embark + Escort	12.8	11.7[c]	--	22.1	--	--
Escort + Manage	13.7	12.9[bc]	--	20.5	--	--
Limit + Banvel + 2,4-D	17.8	16.6[ab]	--	20.6	--	--
MON4625 + 2,4-D + Banvel	18.6	15.9[abc]	--	17.1	--	--
Royal Slo-Gro + 2,4-D	14.7	15.1[abc]	--	22.0	--	--
Shortstop + Banvel	18.6	15.5[abc]	--	21.4	--	--
Telar + Manage	11.2	14.1[bc]	--	18.7	--	--
Control	18.9	19.2[a]	--	25.3	--	--
BLSD (0.05)	NS	4.50	--	NS	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] No evaluations were performed at 6 weeks posttreatment. In addition, destruction of the test area by mowing equipment prematurely terminated this experiment at 9 weeks posttreatment.
NS = Not significant.

Table 69
Mean Seedhead Height of Kentucky Bluegrass at Willow Grove Naval Air Station, Willow Grove, PA, Following Plant Growth Regulator Application on 19 April 1989

Chemical Treatment	Seedhead Height (Weeks Posttreatment), cm					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	0.0	17.9^{cde}[1]	--[2]	28.8^{bc}	--	--
Embark + Escort	0.0	14.0^{e}	--	22.7^{e}	--	--
Escort + Manage	0.0	17.0^{de}	--	23.8^{de}	--	--
Limit + Banvel + 2,4-D	7.8	23.8^{ab}	--	27.5^{bcd}	--	--
MON4625 + 2,4-D + Banvel	0.0	23.9^{ab}	--	24.6^{cde}	--	--
Royal Slo-Gro + 2,4-D	0.0	20.5^{bcd}	--	26.9^{bcde}	--	--
Shortstop + Banvel	0.0	21.9^{bc}	--	29.2^{b}	--	--
Telar + Manage	0.0	20.4^{bcd}	--	26.4^{bcde}	--	--
Control	7.6	27.8^{a}	--	39.3^{a}	--	--
BLSD (0.05)	NS	4.75	--	4.33	--	--

[1] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[2] No evaluations were performed at 6 weeks posttreament. In addition, destruction of the test area by mowing equipment prematurely terminated this experiment at 9 weeks posttreatment.
NS = Not significant.

Table 70
Effects of Plant Growth Regulator Treatments on Turf Color at Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 19 April 1989

Chemical Treatment	Turf Color (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	5.0	8.3[a2]	--[3]	9.0[a]	--	--
Embark + Escort	4.7	6.3[b]	--	9.0[a]	--	--
Escort + Manage	4.7	5.7[b]	--	8.0[ab]	--	--
Limit + Banvel + 2,4-D	6.7	9.0[a]	--	7.7[b]	--	--
MON4625 + 2,4-D + Banvel	6.3	9.0[a]	--	7.7[b]	--	--
Royal Slo-Gro + 2,4-D	7.0	6.3[b]	--	9.0[a]	--	--
Shortstop + Banvel	4.7	8.3[a]	--	8.3[ab]	--	--
Telar + Manage	4.7	6.3[b]	--	8.7[ab]	--	--
Control	7.0	9.0[a]	--	8.3[ab]	--	--
BLSD (0.05)	NS	0.92	--	1.07	--	--

[1] Turf color was evaluated using a visual scale of 1-9 where 1 = severe browning and/or dead turf, 9 = most desirable, 5 = minimally acceptable.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[3] No evaluations were performed at 6 weeks posttreatment. In addition, destruction of the test area by mowing equipment prematurely terminated this experiment at 9 weeks posttreatment.
NS = Not significant.

Table 71
Effects of Plant Growth Regulator Treatments on Weed Control at Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 19 April 1989

Chemical Treatment	Weed Control (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	6.3[ab2]	7.0[ab]	--[3]	5.3[bc]	--	--
Embark + Escort	7.0[ab]	7.0[ab]	--	4.0[cd]	--	--
Escort + Manage	7.7[a]	5.7[bc]	--	3.7[cd]	--	--
Limit + Banvel + 2,4-D	8.0[a]	7.3[a]	--	7.3[a]	--	--
MON4625 + 2,4-D + Banvel	5.0[bc]	7.3[a]	--	6.0[ab]	--	--
Royal Slo-Gro + 2,4-D	6.7[ab]	5.0[cd]	--	3.3[d]	--	--
Shortstop + Banvel	3.0[cd]	4.0[d]	--	3.0[d]	--	--
Telar + Manage	6.7[ab]	4.7[cd]	--	3.0[d]	--	--
Control	1.0[d]	1.0[e]	--	1.0[e]	--	--
BLSD (0.05)	2.47	1.65	--	1.77	--	--

[1] Weed control was evaluated using a visual scale of 1-9 where 1 = no chemical effect, 5 = minimally acceptable, 9 = excellent, no weeds present.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[3] No evaluations were performed at 6 weeks posttreament. In addition, destruction of the test area by mowing equipment prematurely terminated this experiment at 9 weeks posttreatment.

Table 72
Effects of Plant Growth Regulator Treatments on Turf Quality at Willow Grove Naval Air Station, Willow Grove, PA. Treatment Date = 19 April 1989

Chemical Treatment	Turf Quality (Weeks Posttreatment)[1]					
	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk
Event + 2,4-D	5.3	7.7[a2]	--[3]	4.0[a]		
Embark + Escort	4.7	5.7[ab]	--	4.3[a]		
Escort + Manage	5.7	5.7[ab]	--	2.3[bc]		
Limit + Banvel + 2,4-D	6.7	4.0[b]	--	3.3[ab]		
MON4625 + 2,4-D + Banvel	5.3	4.7[b]	--	3.3[ab]		
Royal Slo-Gro + 2,4-D	6.0	5.7[ab]	--	4.0[a]		
Shortstop + Banvel	5.0	5.7[ab]	--	2.0[c]		
Telar + Manage	6.3	5.7[ab]	--	3.3[ab]		
Control	5.3	4.0[b]	--	2.0[c]		
BLSD (0.05)	NS	2.07	--	1.11		

[1] Turf quality was evaluated using a visual scale of 1-9 where 1 = bare ground, dead turf; 5 = minimally acceptable, mowing not yet required; 9 = best quality, optimum greenness, density, and uniformity with excellent vegetative and seedhead suppression and weed control.
[2] Means in the same column followed by the same letter are not significantly different at P = 0.05 level of the (BLSD) test.
[3] No evaluations were performed at 6 weeks posttreatment. In addition, destruction of the test area by mowing equipment prematurely terminated this experiment at 9 weeks posttreatment.
NS = Not significant.

Table 73
Summary of Mowing Activities at Charleston Naval Weapons Station, Charleston, SC

Mowing Category	Site Description	No. of Acres	Mowing Frequency	Cost of Mowing/ Acre, dollars
Level I	Areas around administration buildings; production areas	191	1X/week: Apr - Sept 2X/month: Mar & Oct 1X/month: Nov	14.45
Level IA [1]Section 1	Pomflant security fence perimeter	18	1X/week: Mar & Oct 2X/week: Apr - Sept 1X/week: Nov	14.45
Section 2	Ball field	13	Same frequency as Section 1	22.00
[1]Level II	Pomflant Critical area; ammo magazines and roadsides	482	2X/month: Mar - Sept 1X/month: Oct & Nov	12.00
[1]Level III	Ammo storage magazines and surrounding area	396	1X/month: Mar - Nov	17.00
Level IV	Railroad and *powerline* rights-of-way	45	1X/month: Jun & Dec	50.00
Level V	Building perimeters (low visibility areas)	14	2X/month: May - Sept	50.00
Additional Mowing in Security Area				
[1]	Pomflant Limited Area; ammo storage	586.4	18X/year - Area mowed by gov't forces at an annual cost of $508,934.00 or $48.22/acre	

[1] Potential PGR-use areas.

Table 74
Summary of Mowing Activities at Fort Leonard Wood, MO

Mowing Category	Site Description	No. of Acres	Mowing Frequency	Cost of Mowing/Acre, dollars
Improved	Parade field; high visibility	150	1X/week	12.51
Improved; in housing areas	Playgrounds, cul-del-sacs	21	1X/week	89.25
[1]Category II; Improved	Recreation areas, road shoulders, training areas	348	1X/month	16.11
[1]Category I; semi-improved	Recreation areas, road-sides, training areas (high visibility areas)	892	2X/month	17.28
Category II; semi-improved	Ammo storage, ranges, large fields	337	1X/every two months	9.19
Category II; semi-improved; in housing	Low-use areas behind family housing areas	144	1X/every two months	21.48
Category I; unimproved	Large fields (low visibility areas)	311	1X/every three months	110.00
Category II; unimproved	Utility rights-of-way	115	1X/year	57.04
Category III; unimproved	3rd-class roads; timber trails	22	1X/year	101.30
Golf course	Fairways	60	2X/week	4.43
[1]Golf course	Roughs	120	1X/week	2.48

[1] Potential PGR-use areas.

Table 75
Summary of Mowing Activities at Willow Grove Naval Air Station Willow Grove, PA

Mowing Category	Site Description	No. of Acres	Mowing Frequency	Cost of Mowing/Acre, dollars[1]
0155	Improved lands; lawns at main gate and headquarters	1.4	1X/week	Maintained by military personnel
0156	Improved lands: around buildings and adjacent areas (high visibility)	95	3X/month	59.24
0157[2]	Semi-improved lands: runways and taxiways	115	2X/month: Apr-Jun 1X/month: Jul-Oct	14.81
0158	Unimproved lands: base perimeter road-sides, areas around wind sock and pond	375	2X/season	Cost of mowing operation not available

[1] Costs are estimates from the *Means Landscape Cost Data*.
[2] Potential PGR-use areas.

Table 76
Summary of Mowing Activities at Red River Army Depot Texarkana, TX

Mowing Category	Site Description	No. of Acres	Mowing Frequency	Cost of Mowing/Acre, dollars
Type I[1] Hand rotary	Headquarters, golf course, shop area, water plant, storage igloos, demolition area, Elliott & Caney Lakes	108	Ranges from 1X/week to 1X/month depending on area	23.10
Type II[1] Bush hog	Roadsides, open fields, fencelines, helipad area, fire lanes, surrounding igloo areas	2,703	Ranges from 1X/month to 2X/year depending on area	8.93
Type III Reel mower	Headquarters, golf course	58	Ranges from 1X/week to 1X/year depending on area	14.95
Type IV Flail mower	Headquarters, golf course	81	1X to 2X/week	14.95

[1] Potential PGR-use areas.

Table 77
Chemical Compounds, Formulation, Manufacturer, and Unit Cost of Products Evaluated at All Locations

Trade Name	Formulation[1]	Manufacturer	Unit Cost, dollars[2]
Event	1.46 lb ae/gal[3]	American Cyanamid	260.00 - 270.00/gal
Arsenal	2 lb ae/gal	American Cyanamid	130.00 - 140.00/gal
Banvel	4 lb ai/gal	Sandoz	58.06/gal
Embark	2 lb ai/gal (2S)	PBI Gordon	104.00/gal
Escort	60% dry flowable	DuPont	25.00 - 27.00/oz
Fusilade 2000	1 lb ai/gal (1E)	ICI Americas	76.40/gal
Limit	4 lb ai/gal, flowable	Monsanto	75.00/gal
Manage	75% dry flowable	Monsanto	40.00/lb
MON 4625[4]	4 lb ai/gal	Monsanto	N/A
Oust	75% dispersible granule	DuPont	8.00 - 10.00/oz
Roundup	4 lb ai/gal	Monsanto	53.00 - 55.00/gal
Royal Slo-Gro	1.5 lb ai/gal	Uniroyal	8.00/gal
Shortstop[5]	10% granule (10G)	ICI Americas	N/A
Telar	75% dispersible granule	DuPont	17.00 - 19.00/oz
Trooper	4 lb ai/gal	Monsanto	55.00/gal
2,4-D Amine (WEEDAR® 64)	3.8 lb ai/gal	Rhone-Poulenc	10.50/gal
XE1019[4]	10% wettable powder	Valent	N/A
X-77	liquid; non-ionic spreader (surfactant)	Valent	12.25/gal

[1] ae = acid equivalent.
ai = active ingredient.
[2] Chemical costs were obtained in August 1988 from respective chemical companies and are subject to change depending on purchase quantity and location, bid option, and market value.
[3] Pounds per gallon can be converted to kilograms per liter using conversion factors of 0.4535924 and 3.785412, respectively.
[4] Product under Experimental Use Permit (EUP), prices not available.
[5] Product recently withdrawn from the market, price no longer valid.

Table 78
Number of Mowings and Projected Treatment Costs Per Acre for 12 Weeks on Three Mowing Categories Selected as Candidate Areas for PGR Use at Ft. Leonard Wood, MO

	Category I; Semi-Improved; Recreation Areas, Roadsides, Training Ranges (2X/Month)		Category II; Improved; Recreation Areas, Roadsides, Training Ranges (1X/month)		Golf Course; Roughs (1X/week)	
Treatment	**# of Mows**	**Cost, dollars**	**# of Mows**	**Cost, dollars**	**# of Mows**	**Cost, dollars**
Mowing alone	6	104	3	48	12	30
Event	2	69[1]	1	50	3	27
Embark	2	71	2	68	4	32
Embark + Escort	2	74	1	54	3	32
Embark + Telar	2	71	1	51	3	29
Manage + Telar	2	71	1	51	3	29
Royal slo-Gro +2,4-D	1	69	1	67	2	42
Shortstop + Banvel	3	N/A[2]	2	N/A	6	N/A
XE1019	4	N/A	2	N/A	7	N/A

[1] Cost reflects cost of chemical, application, and any additional mowing required during the 12-week posttreatment evaluation period due to chemical dissipation.
[2] Chemical costs not available.

Table 79
Number of Mowings and Projected Treatment Costs Per Acre for 12 Weeks on Three Mowing Categories Selected as Candidate Areas for PGR Use at Red River Army Depot, Texarkana, TX

	Type I Hand Rotary; Headquarters, Shops, Water & Sewer Plants, etc. (2X/Month)		Type I Hand Rotary; Elliott & Caney Lake, Demo Area, Igloos, etc. (1X/month)		Type II Bushhog; Roadsides, Fire Lanes, Fencelines, Helipad (1X/week)	
Treatment	**# of Mows**	**Cost, dollars**	**# of Mows**	**Cost, dollars**	**# of Mows**	**Cost, dollars**
Mowing alone	6	139	3	69	3	27
Event	3	110[1]	2	87	2	44
Arsenal	2	76	1	53	1	24
Embark + Fusilade	4	132	2	86	2	43
Embark + Oust	3	108	2	85	2	42
Oust	3	101	2	78	2	36
Oust + Escort	2	91	1	68	1	40
Roundup	3	101	2	78	2	35
Roundup + Oust	1	62	1	62	1	34
Roundup + Trooper	3	106	2	83	2	41

[1] Cost reflects cost of chemical, application, and any additional mowing required during the 12-week posttreatment evaluation period due to chemical dissipation.

Table 80
Number of Mowings and Projected Treatment Costs per acre for 12 weeks on One Mowing Category Selected as a Candidate Area for PGR Use at Willow Grove Naval Air Station, Willow Grove, PA

	0157; Semi-improved Lands; Runways and Taxiways (2X/month; Apr-Jun) (1X/month; Jul-Oct)	
Treatment	**Number of Mows**	**Cost, dollars**
Mowing alone	6	89
Event + 2, 4-D	3	82[1]
Embark + Escort	1	43
Escort + Manage	3	78
Limit + Banvel + 2,4-D	3	131
MON4625 + 2,4-D + Banvel	2	N/A[2]
Royal Slo-Gro + 2,4-D	2	79
Telar + Manage	2	63
Shortstop + Banvel	4	N/A

[1] *Cost reflects cost of chemical, application, and any additional mowing required during the* 12-week posttreatment evaluation period due to chemical dissipation.
[2] Chemical costs not available.

Table 81
Number of Mowings and Projected Treatment Costs Per Acre for 12 Weeks on Four Mowing Categories Selected as Candidate Areas for PGR use at Charleston Naval Weapons Station, Charleston, SC

	Level IA Section 1 Pomflant Security Fenceline (2X/week)		Level II Pomflant Ammunition Storage Area (Critical Area) (2X/month)		Level III Ammunition Storage Area (1X/month)		Area Mowed by Gov't Forces Pomflant Ammunition Storage Area (Limited Area) (2X/month)	
Treatment	Number of Mows	Cost, dollars	Number of Mows	Cost, dollars	Number of Mows	Cost, dollars	Number of Mows	Cost, dollars
Mowing alone	24	347	6	72	3	51	6	289
Event	6	119[1]	2	54	1	52	2	162
Embark + Fusilade	14	233	3	65	2	68	3	209
Embark + Oust	8	145	2	51	2	66	2	160
Royal Slo-Gro	6	133	2	68	1	66	2	177
Telar	12	197	3	57	2	60	3	202
Oust	4	77	1	29	1	39	1	101

[1] Cost reflects cost of chemical, application, and any additional mowing required during the 12-week posttreatment evaluation period due to chemical dissipation.

Appendix A
Dominant Grasses, Weed Grasses, and Broadleaf Weed Species at Test Plots

Table A1
Common and Scientific Names and Average Percent Vegetative Cover of the Dominant Grass, Weed Grass, and Broadleaf Weed Species Identified from Test Plots at Fort Leonard Wood, MO

A. Dominant Grass Species: 95%

Kentucky Bluegrass (20%) - *Poa pratensis* L.
Kentucky 31 Tall Fescue (75%) - *Festuca arundinacea* Schreb.

B. Weed Grass Species: 1-5%

Broomsedge - *Andropogon virginicus*
Crabgrass - *Digitaria sanguinalis*
Foxtail - *Setaria* spp.
Orchardgrass - *Dactylis glomerata*
Purpletop - *Tridens flavus* (L.) Hitchc.
Signal Grass - *Brachiaria platyphylla*

C. Broadleaf Weed Species: 1-5%

Common Lespedesa - *Lespedeza striata*
Common Chickweed - *Stellaria media* (L.) Cyrillo
Broadleaf Plantain - *Plantago major* L.
Buckhorn Plantain - *Plantago lanceolata* L.
Bull Nettle - *Solanum carolinense* L.
Dandelion - *Taraxicum officinale*
Field Pansy - *Viola rafinesquii* Greene
Fivefingers Cinquefoil - *Potentilla canadensis* L.
Hop Clover - *Trifolium campestre* Schreb.
Indian Hemp - *Apocynum cannabinum*
Mock Strawberry - *Duchesnea indica* (Andr.) Focke
Red Clover - *Trifolium pratense* L.
Shepherd's purse - *Capsella bursa-pastoris* (L.) Medic.
Sheep Sorrel - *Rumex acetosella* L.
Sulfur Cinquefoil - *Potentilla recta* L.
Vetch - *Vicia* spp.
White Clover - *Trifolium repens*
Wild Potato Vine - *Ipomoea pandurata*
Yarrow - *Achillea millefolium* L.
Yellow Nutsedge - *Cyperus esculentus* L.
Yellow Sweetclover - *Melilotus officinalis* (L.) Lam.
Yellow Wood-sorrel - *Oxalis stricta*

Table A2
Common and Scientific Names and Average Percent Vegetative Cover of the Dominant Grass, Weed Grass, and Broadleaf Weed Species Identified from Test Plots at the Red River Army Depot, Texarkana, TX

A. Dominant Grass Species: 1-55%
Common Bermudagrass - *Cynodon dactylon* (L.)Pers.
B. Weed Grass Species: 1-40%
Brome - *Bromus* spp. Crabgrass - *Digitaria sanguinalis* Dallisgrass - *Paspalum dilatatum* Poir. Foxtail - *Setaria* spp. Lovegrass - *Eragrostis* spp. Quaking grass - *Briza maxima* Ryegrass - *Lolium* spp. Smutgrass - *Sporabolus poiretii* Three-awn - *Aristida* spp. Witchgrass - *Panicum* spp.
C. Broadleaf Weed Species: 1-5%
Bitter sneezeweed - *Helenium amarum* Blackberry - *Rubus* spp. Black medic - *Medicago lupulina* Bluets - *Hedyotis crassifolia* Raf. Bracted plantain - *Plantago aristata* Bull thistle - *Cirsium vulgare* Buttonweed - *Diodia teres* Carolina geranium - *Geranium carolinianum* L. Calliopsis - *Coreopsis basalis* (Dietr.) Blake Curly dock - *Rumex crispus* L. Daisy fleabane - *Erigeron annuus* L. Dichondra - *Dichondra repens* Field madder - *Sherardia arvensis* L. Lespedeza - *Lespedeza* spp. Milkweed - *Asclepias* spp. Mimosa - *Albizzia julibrissin* Nightshade - *Solanum* spp. Oxeye daisy - *Chrysanthemum leucanthemum* L. Prostrate spurge - *Euphorbia supina* Raf. Rabbit tobacco - *Gnaphalium obtusifolium* Shepherd's purse - *Capsella bursa-pastoris* Virginia Buttonweed - *Diodia verginiana* L. White clover - *Trifolium repens* L. Wood sorrel - *Oxalis* spp. Yellow nutsedge - *Cyperus esculentus* L.

Table A3
Common and Scientific Names and Average Percent Vegetative Cover of the Dominant Grass, Weed Grass, and Broadleaf Weed Species Identified from Test Plots at the Charleston Naval Weapons Station, Charleston, SC

A. Dominant Grass Species: 95-98%

Bahiagrass - *Paspalum notatum*

B. Weed Grass Species: 1-5%

Eastern Gamagrass - *Tripsacum dactyloides* L.
Smutgrass - *Sporabolus* spp.
St. Augustine - *Stenotaphrun secundatum*
Vasey grass - *Paspalum urvillei*

C. Broadleaf Weed Species: 1-5%

Bluehearts - *Buchnera floridana*
Butterfly pea - *Clitoria mariana*
Bull nettle - *Cnidoscolus stimulosus*
Cat greenbrier - *Smilax glauce*
Common chickweed - *Stellaria media* (L.) Cyrillo
Daisy fleabane - *Erigeron annuus* (L.) Pers.
Dichondra - *Dichondra repens*
Dogfennel - *Eupatorium capillifolium*
Dwarf dandelion - *Krigia montana*
False garlic - *Nothoscordum bivalve* (L.) Britt
Geranium - *Geranium carolinianum*
Groundsel - *Senecio* spp.
Milkweed - *Asclepias* spp.
Nightshade - *Solanum* spp.
Peppervine - *Ampelopsis arborea*
Persimmon - *Diospyros virginiana*
Rabbit tobacco - *Gnaphalium obtusifolium*
Rattlebox - *Crotalaria sagittalis*
Sedge - *Cyperus compressus*
Skullcap - *Scutellaria* spp.
Thistle - *Cirsium* spp.
Yellow nutsedge - *Cyperus esculentus* L.
Yellow woodsorrel - *Oxalis dillenii* Jacq.

Table A4
Common and Scientific Names and Average Percent Vegetative Cover of the Dominant Grass, Weed Grass, and Broadleaf Weed Species Identified from Test Plots at the Willow Grove Naval Air Station, Willow Grove, PA

A. Dominant Grass Species: 90%

Kentucky Bluegrass (30%) - *Poa pratensis* L.
Kentucky 31 Tall Fescue (60%) - *Festuca arundinacea* Schreb.

B. Weed Grass Species: 1-5%

Brome - *Bromus* spp.
Crabgrass - *Digitaria sanguinalis*
Foxtail - *Seteria* spp.
Little Barley - *Hordeum pusillum*
Orchardgrass - *Dactylis glomerata* L.
Velvet grass - *Holcus lanatus*

C. Broadleaf Weed Species: 1-5%

Birdfoot Tefoil - *Lotus corniculatus*
Black-eyed Susan - *Rudbeckia hirta* L.
Black Medic - *Medicago lupulina*
Broadleaf Plantain - *Plantago major* L.
Buckhorn Plantain - *Plantago lanceolata* L.
Bullnettle - *Solanum carolinense* L.
Chickweed - *Stellaria media*
Chicory - *Cichorium intybus* L.
Common Blue Violet - *Viola papilionacea* Pursh.
Common Cinquefoil - *Potentilla simplex*
Curly Dock - *Rumex crispus*
Daisy Fleabane - *Erigeron annuus*
Dandelion - *Taraxacum officinale*
Field Bindweed - *Convolvulus arvensis* L.
Field Pussytoes - *Antennaria neglecta*
Foxglove Beardtongues - *Penstemon digitalis*
Hawkweed - *Hieracium pratense* Tausch
Heal All - *Prunella vulgaris*
Hop Clover - *Trifolium procumbens* L.
Loosestrife - *Lythrum* spp.
Milkweed - *Ampelamus albidus*
Nutsedge - *Cyperus* spp.
Oxalis - *Oxalis* spp.
Ox-eye Daisy - *Chrysanthemum leucanthemum* L.
Queen Anne's Lace - *Daucus carota* L.
Red Clover - *Trifolium pratense*
St. Johnswort - *Hypericum perforatum* L.
Thistle - *Cirsium* spp.
Wild Garlic - *Allium canadense*
Wild Strawberry - *Fragaria virginiana* D.
White Clover - *Trifolium repens*
Yarrow - *Achillea millefolium* L.

Appendix B
Product Information

Arsenal

Active Ingredient(s): Isopropylamine salt of imazapyr

Formulation: Liquid; 27.6 percent active ingredient

Manufacturer: American Cyanamid Company, Wayne, NJ

Uptake and Mode of Action: Foliar and root uptake; disrupts protein synthesis through inhibition of the enzyme, acetohydroxyacid synthase, which is necessary for production of three amino acids (valine, leucine, and isoleucine)

Susceptible Species: Broad-spectrum herbicide; effective on many broadleaf and grass weed species; applying low rates of this product as a pre-greenup treatment on bermudagrass is being evaluated

Registered Use: Herbicide

Half Life in Soil: Greater than 3 months, depending on environmental conditions

Banvel

Active Ingredient(s): Dicamba

Formulation: Granular; 10 percent active ingredient by weight, liquid; 48.2 percent active ingredient

Manufacturer: Sandoz Crop Protection Corporation, Des Plaines, IL

Uptake and Mode of Action: Foliar and root uptake; auxin-like growth regulator; causes epinasty (downward bending of plant due to rapid cell elongation on one side of the plant stem), leaf cupping, and eventual plant death

Susceptible Species: Will control or suppress the growth of many annual, biennial, and perennial broadleaf weeds, and many woody brush and vine species

Registered Use: Herbicide

Half Life in Soils: Less than 14 days under conditions amenable to rapid metabolism

Embark

Active Ingredient(s): Mefluidide

Formulation: Liquid; 28 percent active ingredient, formulated as the diethanolamine salt in aqueous solution (2-S)

Manufacturer: Agricultural Products/3M, St. Paul, MN; distributed by PBI/Gordon Corporation, Kansas City, KS

Uptake and Mode of Action: Foliar uptake; interrupts cell division thus inhibiting growth and development of the meristematic regions; when applied to turf grasses, vegetative growth is reduced and seedhead production suppressed

Susceptible Species: Kentucky and annual bluegrass, tall, red and chewings fescue, perennial ryegrass; some effectiveness on warm season grasses; also for use on various ornamental shrubs, hedges, trees, and ground cover

Registered Use: Plant growth regulator

Half Life in Soil: Less than 1 week

Escort

Active Ingredient(s): Metsulfuron methyl

Formulation: Dry flowable; 60 percent active ingredient

Manufacturer: DuPont Company, Wilmington, DE

Uptake and Mode of Action: Foliar and root uptake; inhibits acetolactase synthase, a plant enzyme needed for amino acid synthesis; results in rapid cessation of growth and eventual plant death; if used at low rates, will provide selective weed control and growth suppression/seedhead inhibition of some desirable turfgrass species

Susceptible Species: Effective on various broadleaf and grass weed species; low rates will suppress growth and seedhead production of fescue and bluegrass turfs

Registered Use: Herbicide

Half Life in Soils: 4-6 weeks

Event, ACP1911

Active Ingredient(s): Ammonium salt of imazethapyr and ammonium salt of imazapyr

Formulation: Liquid; 18 percent (imazethapyr, 17.26 percent; imazapyr, 0.64 percent) active ingredients

Manufacturer: American Cyanamid Company, Wayne, NJ

Uptake and Mode of Action: Foliar uptake; disrupts protein synthesis by inhibiting production of three amino acids (valine, leucine, and isoleucine); results in reduced foliar growth and control and suppression of seedhead production

Susceptible Species: Tall fescues, perennial ryegrasses, bluegrasses, and bahiagrass

Registered Use: Grass growth regulator

Half Life in Soil: Greater than 3 months

Fusilade

Active Ingredient(s): Fluazifop-P-butyl

Formulation: Liquid; 13 percent active ingredient

Manufacturer: ICI Americas Inc., Wilmington, DE

Uptake and Mode of Action: Foliar uptake; inhibits growth in the meristematic region resulting in death of the plant

Susceptible Species: Many annual and perennial grasses (weedy grasses, such as johnsongrass)

Registered Use: Herbicide

Half Life in Soil: Less than 1 week in moist soils; the major degradation product, fluazifop, has a half-life of 3 weeks

Limit

Active Ingredient(s): Amidochlor

Formulation: Liquid; 41.6 percent active ingredient

Manufacturer: Monsanto Company, St. Louis, MO

Uptake and Mode of Action: Primarily root uptake; inhibits cell division resulting in suppression of vegetative growth and seedhead production

Susceptible Species: Cool-season grasses only: Kentucky bluegrass, tall and fine fescues, and perennial ryegrass

Registered Use: Turf regulator

Half Life in Soil: Less than 1 week

Manage

Active Ingredient(s): Glyphosate as the sodium sesqui salt

Formulation: Liquid; 75 percent active ingredient

Manufacturer: Monsanto Company, St. Louis, MO

Uptake and Mode of Action: Foliar uptake; appears to inhibit amino acid and protein synthesis; suppresses vegetative growth and seedhead development

Susceptible Species: Tall fescue and smooth brome

Registered Use: Industrial turf growth regulator

Half Life in Soil: Less than 60 days

MON 4625

Active Ingredient(s): Amidochlor and Paclobutrazol

Formulation: Liquid; percent active ingredient not available

Manufacturer: Monsanto Company, St. Louis, MO

Uptake and Mode of Action: Primarily root uptake; Amidochlor - inhibits cell division; Paclobutrazol - inhibits gibberellin synthesis; activity of both compounds together results in reduced vegetative growth and suppressed seedhead production

Susceptible Species: Cool-season grasses only: Kentucky bluegrass, tall and fine fescues, and perennial ryegrass

Registered Use: Currently not registered; experimental use compound

Half Life in Soil: 20-26 weeks

Oust

Active Ingredient(s): Sulfometuron methyl

Formulation: Dispersible granules; 75 percent active ingredient

Manufacturer: DuPont Company, Wilmington, DE

Uptake and Mode of Action: Foliar and root uptake; inhibits acetolactase synthase, a plant enzyme needed for amino acid synthesis; results in rapid cessation of growth through inhibition of cell division and eventual plant death; if used at low rates, will provide selective weed control and growth suppression/seedhead inhibition of some desirable turfgrass species

Susceptible Species: Herbicide activity on many annual and perennial grasses and broadleaf weeds; effective at low rates for selective weeding or release of bermudagrass, bahiagrass, smooth bromegrass and crested wheatgrass turfs

Registered Use: Herbicide

Half Life in Soil: 4-6 weeks

Roundup

Active Ingredient(s): Isopropylamine salt of glyphosate

Formulation: Liquid; 41 percent active ingredient

Manufacturer: Monsanto Company, St. Louis, MO

Uptake and Mode of Action: Foliar uptake; inhibits the biosynthesis of aromatic amino acids through inhibition of necessary enzyme systems

Susceptible Species: Relatively nonselective; effective on perennial, annual, and biennial species of grasses, sedges, and broad-leaved weeds

Registered Use: Herbicide

Half Life in Soil: Less than 60 days

Royal Slo-Gro

Active Ingredient(s): Potassium salt of maleic hydrazide

Formulation: Liquid; 21.7 percent active ingredient

Manufacturer: Uniroyal Chemical Company, Middlebury, CT

Uptake and Mode of Action: Foliar uptake; a uracil antimetabolite; inhibits cell division in meristematic regions resulting in reduced vegetative growth and suppression of seedhead formation

Susceptible Species: Bluegrasses, fescues, bromegrass, orchardgrass, quackgrass, perennial rye, ryegrass and bahiagrass; also effective on some shrubs, trees, and ornamentals

Registered Use: Growth retardant

Half Life in Soil: 2-8 weeks for typical soils

Short-stop

Active Ingredient(s): S-ethyl dipropylthiocarbamate; also EPTC, Eptam

Formulation: Granular; 10 percent active ingredient

Manufacturer: Discontinued by Stauffer Chemical Company

Uptake and Mode of Action: Root uptake; inhibits growth in the meristematic region of grass leaves; however, specific mode of action unknown

Susceptible Species: Tall fescue

Registered Use: Grass growth regulator (formulation currently unavailable)

Half Life in Soil: Approximately 1 week

2,4-D Amine, Weedar 64

Active Ingredient(s): Dimethylamine salt of 2,4-Dichlorophenoxyacetic acid

Formulation: Liquid; 46.8 percent active ingredient

Manufacturer: Rhone-Poulenc Ag Company, Research Triangle Park, NC

Uptake and Mode of Action: Foliar uptake; causes abnormal growth and affects respiration, food reserves, and cell division; but the primary mode of action has not been clearly established

Susceptible Species: Many annual and perennial broad-leaved species

Registered Use: Broadleaf herbicide

Half Life in Soil: 1-4 weeks

Telar

Active Ingredient(s): Chlorsulfuron

Formulation: Dispersible granules; 75 percent active ingredient

Manufacturer: DuPont Company, Wilmington, DE

Uptake and Mode of Action: Foliar and root uptake; inhibits acetolactase synthase, a plant enzyme needed for amino acid synthesis; results in rapid cessation of growth through inhibition of cell division and eventual plant death; low rates will provide selective weed control on some turfs

Susceptible Species: Herbicide activity on many annual and perennial grasses and broadleaf weeds; effective at low rates for selective weeding on bermudagrass, bahiagrass, bluegrass, wheatgrass, smooth brome and fescue turfs

Registered Use: Herbicide

Half Life in Soil: 4-6 weeks

Trooper

Active Ingredient(s): Dimethylamine salt of 3,6-dichloro-o-anisic acid (dicamba) and dimethylamine salts of related acids

Formulation: Liquid; 48.2 percent active ingredient

Manufacturer: Monsanto Company, St. Louis, MO

Uptake and Mode of Action: Foliar and root uptake; auxin-like growth regulator; causes epinasty (downward bending of plant due to rapid cell elongation on one side of the plant stem), leaf curling, and eventual plant death

Susceptible Species: Will control or suppress the growth of many annual, biennial, and perennial broadleaf weeds, and many woody brush and vine species

Registered Use: Herbicide

Half Life in Soils: Less than 14 days under conditions amenable to rapid metabolism

XE1019

Active Ingredient(s): Uniconizole

Formulation: Wettable powder; 10 percent active ingredient

Manufacturer: Valent USA Corporation, Walnut Creek, CA (formerly Chevron Chemical Company - Agricultural Chemical Division)

Uptake and Mode of Action: Root uptake; inhibits synthesis of the plant hormone, gibberellin, which is necessary for stem elongation

Susceptible Species: Ornamentals, turf species, wheat, barley, rice, sorghum, and a variety of grassy and broadleaf weed species

Registered Use: Experimental plant growth regulator; currently not registered

Half Life in Soil: Greater than 6 months

X-77

Active Ingredient(s): Alkylarylpolyoxyethylene, glycols, free fatty acids, and isopropanol

Formulation: Liquid, 90 percent of ingredients effective as a spray adjuvant

Manufacturer: Chevron Chemical Company, San Francisco, CA

Uptake and Mode of Action: Provides quick wetting of plant surfaces to enhance herbicide uptake, more uniform coverage, and increased retention of sprays by reducing surface tension of the spray droplets

Susceptible Species: For use with agricultural herbicides, insecticides, and fungicides

Registered Use: Non-ionic spreader (surfactant)

Half Life in Soil: Not available