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Determination of Spring Application Timing and Concentration for Use of ACP1911 (Event) at Coles County Airport, Illinois

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Determination of Spring Application Timing and Concentration for Use of ACP1911 (Event) at Coles County Airport, Illinois

(TITLE)

BY

Robert D. Kuhajda, Jr.

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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Abstract

A field test was conducted to determine the most effective spring application timing and the most effective concentration for use of American Cyanamid's ACP1911 plant growth regulator. Three different concentrations of ACP 1911, also known as Event, were used for each of five different dates. The field test was conducted on rough turf at Coles County Airport, Illinois, in the spring and summer of 1987.

The dominant grasses in the test site were fescue (Festuca pratensis Huds.) and bluegrass (Poa pratensis L.).

Event was applied at concentrations of six, eight and ten ounces per acre on March 11, April 3, April 17, May 1 and May 16. Embark, a product of 3M Company, was applied for comparison on May 1.

Event was evaluated for the reduction in weight, from control, of material harvested from the test plots. Subjective tests on the height, injury, color, seedhead production, and weed control in the test plots were also conducted to support the weight studies. These common subjective tests are included for completeness.

It appeared that Event was most effective when applied at a concentration of ten ounces per acre regardless of application timing. Weight studies also indicate that, as time passes, later application dates become more effective than the previous dates; however, the overall percent

reduction falls off. For the 5/14 sample date, the April 17 application date is most effective producing an 81% reduction from the control. For sample date 6/10, the May 1 application date is most effective producing a 78% reduction. Finally, the 7/10 sample date indicates application date 5/16 is most effective, producing only a 42% reduction. The subjective study on turf height supports the data from the weight studies. Later application dates also were more effective than previous dates, as time passed. Event, when used at the most effective concentration and applied at the most effective date, was superior to Embark at the reduction of turf growth.

Introduction

Event consists of the ammonium salts of two imidizolinone compounds, imazapyr and imayethapyr (Table 1). These two compounds are known to control the growth of many monocots and herbaceous and woody dicots (American Cyanamid Co., 1985 A, B and C, 1986). Selectivity is by the differential metabolism of imidizolinones to nonherbacidal forms by the different species (Shaner, et al., 1984). Event was recommended for use on tall fescue, perennial ryegrass, bluegrass and bahiagrass in limited care-low maintenance areas and limited wear areas (American Cyanamid Co., 1988).

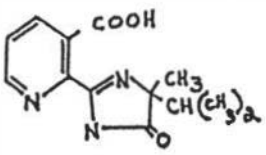
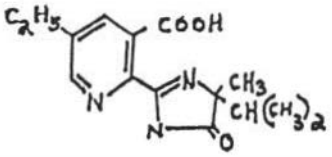
Imidizolinones regulate plant growth by inhibiting the action of acetohydroxyacid synthase (Shaner, et al., 1984 and 1985). Acetohydroxyacid synthase is an enzyme within the common pathway for the synthesis of the aliphatic, branched chained amino acids leucine, isolencine and valine (Miflin and Lea, 1982).

Imazapyr is absorbed through roots and foilage of plants and is accumulated in meristematic regions (Shaner, et al., 1985 and Van Cantfort, et al., 1986). Once in the soil, lateral and vertical movement was limited, 80 to 90% remained in the top six inches of soil after one year and no active ingredient was noted more than three inches outside the study area in a field test by Van Cantfort, et al., (1986).

Imazapyr was translocated at a steady rate out of the leaves for four days after treatment, so subsequent translocation was noted after four days. Translocation was found to be equal to above and below ground portions of the plant (Shaner, et al., 1985).

In laboratory study imazapyr was found to be stable in water and in pH5, 7 and 9 buffered solutions when stored in the dark. However, when exposed to sunlight the active ingredient rapidly degraded. A half life of 3.7, 5.3 and 2.5 days was determined from a twelve hour exposure period for imazapyr when in distilled water, pH5 and pH7 buffered solution respectively (American Cyanamid Co., 1985 B and C). High temperature and high soil moisture increases degradation although in field studies activity persists for three months to two years (American Cyanamid Co., B and C).

Table 1. The Components of ACP1911.

	Imazapyr	Imazethapyr
chemical family	Imidizolinone	Imidizolinone
modecular formula	$C_{13}H_{15}N_3O_3$	$C_{15}N_{19}N_3O_3$
structural formula		
IUPAC name	2 (4-isopropyl-4-methyl-5-oxo-2-imidizolin-2-yl) nicotinic acid	5 ethyl-2-(4-isopropyl-4-methyl-5-oxo-2 imidizolin-2-yl) nicotinic acid
CA name	2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl] -3-pyridinecarboxylic acid	2-[4,5-dihydro-4-methyl-4-(1-methyletyl)-5-oxo--1H-imidazol-2-yl] -5-ethyl-3-pyridinecarboxylic acid
molecular weight	261.3	289.3
melting point	160-173°C	172-175°C
solubility	1-1.5% in H_2O at 25°C	1415ppm in H_2O at 25°C
physical state	white to tan powder, slightly acetic acid odor	white to off white, crystaline solid, odorless
partition coefficient	1.3 at 22°C	not available
pH	3.0-3.5 at a 1% solution in H_2O at 25_oC	not available
stability	18 months minimum at 25_oC	not available
EPA registration #	241-273 (noncrop use)	not available
other names	Arsenal; chopper; AC252,925; CL252,925	Pursuit; CL263,499; AC263,499
	(American Cyanamid Co., 1985A, 1988)	(American Cyanamid Co., 1985C, 1988)

Methods

The test plots were established at Coles County Airport, 5 miles west of Charleston, Illinois and 2.5 miles east of Mattoon, Illinois on U. S. Route 16, map coordinates R8E, T12N (Illinois State, 1965). The plots were 30 feet by 6 feet with a three foot zone between each plot and a fifteen foot border around the test area. There were a total of 63 plots, 21 in each of three repetitions. Each repetition consisted of 15 treatments of the plant growth regulator (PGR) ACP1911 applied on five different dates at three separate concentrations. Embark was also applied once for comparison. The remaining plots were used as controls.

Prior to staking out the plots, the turf was cut to a uniform height of two inches on December 19, 1986, the winter before the field tests were to be conducted. This was done to ensure an equal baseline for all tests. The cuttings were removed from the test area.

Random soil samples were also taken December 19, 1986, to determine the substrate of the turf.

Soil pH was determined by thoroughly mixing 40 mls of distilled water with 20 g of air dried soil and leaving the mixture to equilibrate for 12 hours. The soil solution was then remixed and pH was determined using a Corning model 7 pH meter (Page et al., 1965).

Soil texture was determined by the Bouyoucos hygrometer method (Bouyoucos, 1962). Air dried soil was sieved through a U. S. #10 sieve. Fifty grams of soil were added to 30 ml of 1 M Na_2CO_3 dispersing agent and 20 ml of distilled water and the solution was then mixed in a blender for two minutes. This mixture was then transferred to a graduated cylinder and the total volume was increased to one liter with distilled water. Hygrometer readings were taken at 40 seconds, 4.5 minutes and 1 hour.

The amount of soil organic matter was determined by colorimetric assay. Air dried soil was sieved through a U.S. #10 sieve. One gram of soil was combined with 10 ml of 1 N $K_2Cr_2O_7$ and 10 ml of concentrated sulfuric acid and then left for 30 minutes. Eighty milliliters of distilled water were then added. The soil mixture was vacuum filtered. Optical density was determined using a Bauch and Lomb spectronic-20 zeroed and 600 nm. Control solutions of one, three and five percent sucrose were made, and optical density recorded, to construct a standard curve for comparison (Page et al., 1965).

Event, obtained from American Cyanamid Company, was applied in concentrations of 6, 8 and 10 ounces per acre in a volume of 30 gallons per acre as requested by American Cyanamid Company. Embark was also applied in a volume of 30 gallons per acre, at a concentration of 24 ounces per acre as was recommended by label instructions. Event was

applied on March 11, April 3, April 17, May 1 and May 16. These dates are roughly comparable to 5%, 40%, 80%, 100% and 100% of turf "greenup" respectively. Effort was made to space application dates at two week intervals, weather permitting (Table 2). Embark was applied on May 1, after 100% greenup as was suggested by the label instructions. Test plots were assigned at random.

A hand-held spray boom was used to apply the plant growth regulators. This apparatus consisted of four nozzles, each 20 inches apart on a boom, several two liter bottles containing the material to be applied and a pressurized bottle of CO_2 to discharge the plant growth regulators. The nozzles were single aperture with a 110^{o} angle of application, Teejet Model 110035. To allow for a 30% overlap, the boom was held 10 to 12 inches above the turf. For proper application rate the PGR's were applied with 40 psi boom pressure at three miles per hour.

Prior to sampling, each plot was divided into subplots of 6' x 15', 6' x 7.5' and 6' x 7.5'. One 6' x 7.5' subplot was used to determine turf production by weight from clippings collected by a bagging mower cutting to two inches. These subplots were cut to two inches on April 29, 1987. Those subplots yet to be treated with a PGR were again cut to two inches two days before PGR application. This practice of cutting the turf two days prior to application of a PGR was recommended for Embark in label

Table 2. Detailed calendar of methods used in the study of plant growth regulator ACP1911 (Event) at Coles County Airport, Illinois.

December 19, 1986: Test area was mowed to two inches, test plots were staked out and soil samples were taken.

March 11, 1987, 3:11 p.m.: First application of ACP1911. Approximately 5% greenup. Soil and air temperature 5° C. Wind speed was negligible.

March 24 through April 2, 1987: Rain and wind speeds over 20 mph prohibited PGR application.

April 3, 1987, 3:30 p.m.: Second application of ACP1911. Approximate greenup 40%. Soil and air temperature 5° C. Wind speed 6 mph with gusts to 21 mph.

April 17, 1987, 3:00 p.m.: Third application of ACP1911. Approximate greenup 80%. Soil temperature 16° C, air temperature 19° C. Wind speed was negligible.

April 29, 1987: Plots were divided into subplots. One subplot per plot for weight studies and two for observational studies. The subplot for weight studies and one subplot for observational studies were cut to two inches. The other subplot for observational studies was left uncut.

May 1, 1987, 3:00 p.m.: Fourth application of ACP1911, only application of Embark. Approximate greenup 100%. Soil temperature 24° C, air temperatures 25° C. Wind speed 8 to 12 mph.

May 14 ,1987: Subplots for weight study for the May 16 application of ACP1911 were cut. Weight samples were collected for controls and plots where PGR's were previously applied. Visual studies of turf height and seedhead reduction.

May 16, 1987, 3:00 p.m.: Fifth and final application of ACP1911. Approximate greenup 100%. Soil and air temperature 26°C. Wind speeds of 5 to 10 mph.

May 21, 1987: Visual studies of height of turf, seedhead reduction of turf and injury to turf were conducted.

May 29, 1987: Visual studies of height of turf, seedhead reduction of turf, injury to turf and weed reduction in turf were conducted.

Table 2. (continued)

June 10, 1987: Collection of samples for weight study and visual study of injury to turf were conducted.

June 11, 1987: Visual studies and height and seedhead reduction of turf were conducted.

June 20, 1987: Visual studies of height of turf, seedhead reduction of turf, injury to turf and weed reduction of turf were conducted.

July 2, 1987: Visual studies of height and weed reduction of turf.

July 10, 1987: Collection of samples for weight study.

August 18, 1987: Collection of samples for weight study.

instructions and was therefore used in subsequent Event application.

The second 6' x 7.5' subplots were also cut to two inches on April 29, 1987. These subplots were used for subjective visual observations of height of turf, seedhead production of turf, color of turf, injury of turf and weed control in turf. Subjective studies were conducted by visual comparison with controls. Studies of height of turf and seedhead production of turf were made by estimating the percent reduction of these factors when compared to control.

The third subplots (6' x 15') were used for visual observations as listed above. These subplots were not cut during the experiments.

Observational studies for the cut and uncut plots were taken on May 14, May 21, May 29, June 11, June 20 and July 2.

Results

The soil samples from the test sites indicate a substrate with a pH of 6.1, organic matter content of 3.1% and a silty clay/silty clay loam texture (Table 3).

The average weight, in grams, and the percent reduction from control of samples collected from the test plots are listed in Table 4. Wet weight of samples was recorded. On sample date 5/14, ten ounces per acre (10 oz./A) was the most effective concentration for application dates 3/11, 4/17 and 5/1. Eight ounces per acre was marginally more effective than 10 oz./A for application date 4/3. Application date 4/17 showed the greatest suppression (Figure 1). The most effective concentration of event for all application dates were superior to Embark, 25% to 81% reduction in weight for Event to 14% reduction for Embark.

For weight samples collected on 6/10, 10 oz./A is the most effective concentration of Event for application dates 3/11, 4/17 and 5/1 and 8 oz./A for application date 4/3 as in the first sample date. Six ounces per acre proved the most effective concentration of Event for the 5/16 application date (Figure 2). Only application dates 5/1 and 5/16 contained samples more effective then Embark and only in application date 5/1 were all concentrations tested more effective than Embark. Application date 3/11, at all concentrations, and the two least effective concentrations

Table 3. Soil Analysis from test area at Coles County Airport. The analysis was performed to determine substrate for testing plant growth regulator ACP1911 on rough turf. Soil samples were collected on December 19, 1986.

Soil pH	= 6.1
Soil texture	= silty clay/silty clay loam
	16% sand
	44% silt
	40% clay
Soil organic matter	= 3.1%

Table 4 . The average weight, in grams, and percent reduction from control of grass cuttings collected from rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The turf was cut to two inches for a 6 foot by 7.5 foot area of the sample plots. Embark was also applied for a comparison.

Application date & concentration	Average weight in grams of sample and percent reduction from control by date collected							
	5/14		6/10		7/10		8/18	
	g	% reduction	g	% reduction	g	% reduction	g	% reduction
3/11, 6 oz/A	157.4	9	89.7	--	204.7	18	907.7	64
3/11, 8 oz/A	170.1	1	79.5	--	261.8	--	2390.3	3
3/11, 10 oz/A	129.3	25	66.0	--	217.9	13	521.1	79
4/3, 6 oz/A	115.2	33	72.5	--	235.7	5	1192.9	52
4/3, 8 oz/A	76.0	56	57.7	5	175.7	29	1121.8	55
4/3, 10 oz/A	81.7	53	83.1	--	236.8	5	1304.4	47
4/17, 6 oz/A	58.2	66	56.8	6	219.1	12	781.0	68
4/17, 8 oz/A	47.3	73	45.8	24	195.6	22	872.7	65
4/17, 10 oz/A	33.2	81	41.3	32	194.6	22	1035.9	58
5/1, 6 oz/A	131.1	24	28.4	53	250.5	--	2067.9	16
5/1, 8 oz/A	74.4	57	27.2	55	167.1	33	1592.0	36
5/1, 10 oz/A	62.7	64	13.1	78	164.4	34	1202.1	51
5/16, 6 oz/A			28.4	53	183.7	26	1380.4	44
5/16, 8 oz/A			49.0	19	213.1	14	982.0	60
5/16, 10 oz/A			50.8	16	143.0	42	895.8	64
Embark 5/1, 24 oz/A	149.1	14	32.2	47	193.9	22	825.9	66
Control	172.5		60.4		248.3		2473.0	

Figure 1 The average weight, in grams, of grass cuttings collected from rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The turf was cut to two inches for a 6 foot by 7.5 foot area of the sample plots. Embark was also applied for a comparison. Samples were collected on May 14, 1987.

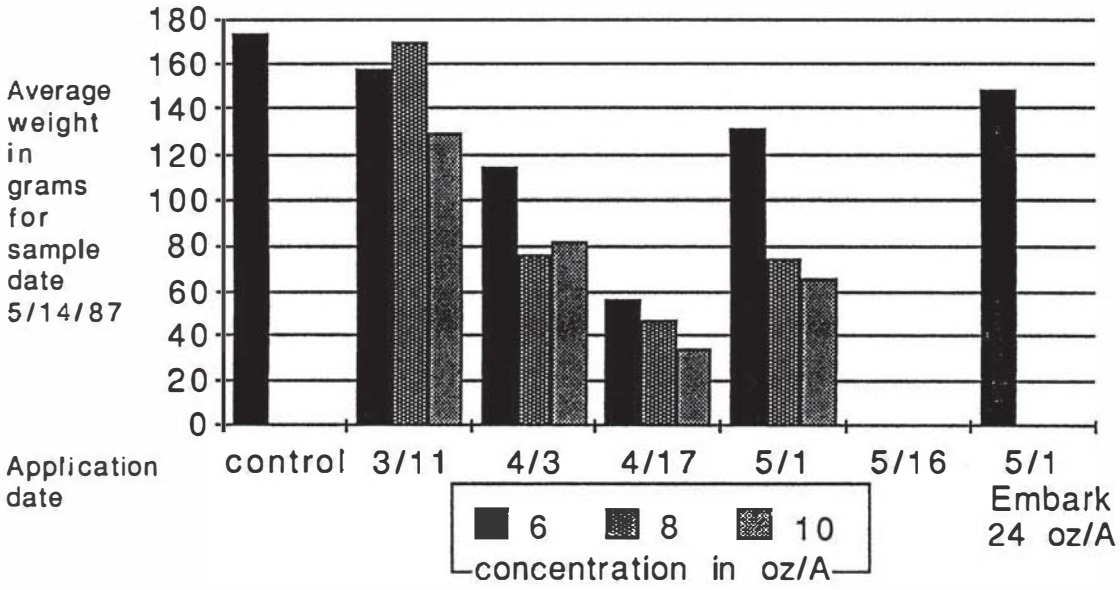
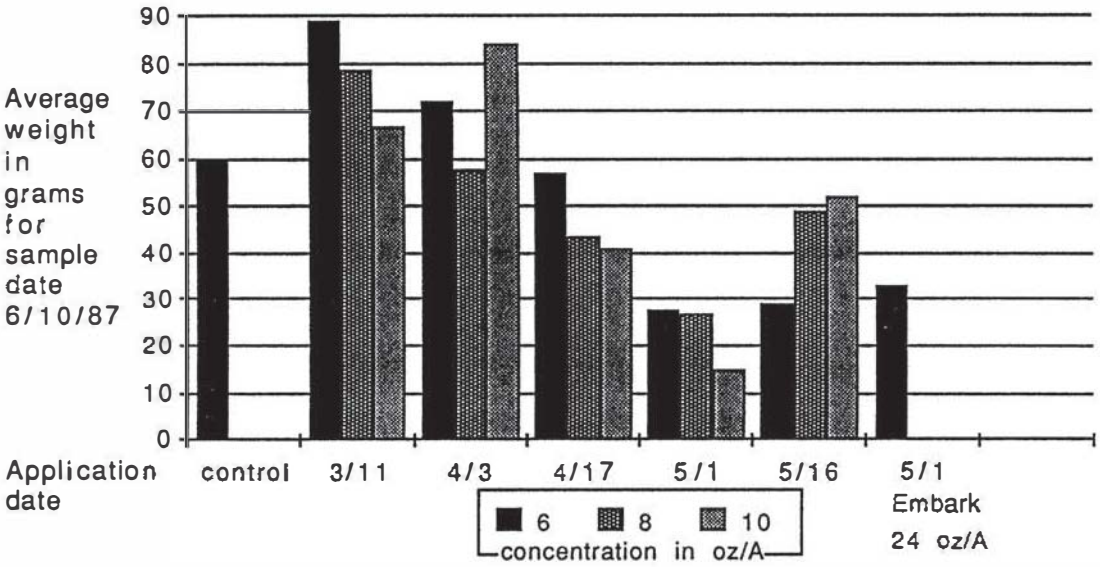


Figure 2 The average weight, in grams, of grass cuttings collected from rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The turf was cut to two inches for a 6 foot by 7.5 foot area of the sample plots. Embark was also applied for a comparison. Samples were collected on June 10, 1987.



for application date 4/3 yielded an average weight per plot greater than that of the control. Application date 5/1 proved, by far, the most effective for this sample date, 78% reduction from control at 10 oz./A.

By sample date 7/10 PGR activity seemed to be limited. Although only two samples yielded an average weight of cuttings greater than control, only three samples showed a 33% reduction or greater. Ten ounces per acre was the most effective concentration for sample dates 5/1 and 5/16. Sample date 4/17 indicated an equal percent reduction from control for 8 and 10 ounces per acre. Six ounces per acre proved most effective for application date 3/11 and 8 oz./A for application date 4/3 (Figure 3). Application date 5/16 showed the most effective percent reduction from control at 42% for 10 oz./A.

It was clearly evident at the test site that by 8/18 the PGR activity was severely limited. Although all plots showed a reduction in weight from control (Figure 4) only one of the three repetitions was harvested due to the difficulty in handling such large quantities of cuttings. Therefore the researcher is not confident of the data and these numbers may not be a clear indication of the PGR effects of this late date. However, it should be stressed that there was reduction in weight from the control.

Subjective visual studies on the average percent reduction in height of turf from the plots that were not

Figure 3 The average weight, in grams, of grass cuttings collected from rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The turf was cut to two inches for a 6 foot by 7.5 foot area of the sample plots. Embark was also applied for a comparison. Samples were collected on July 10/1987.

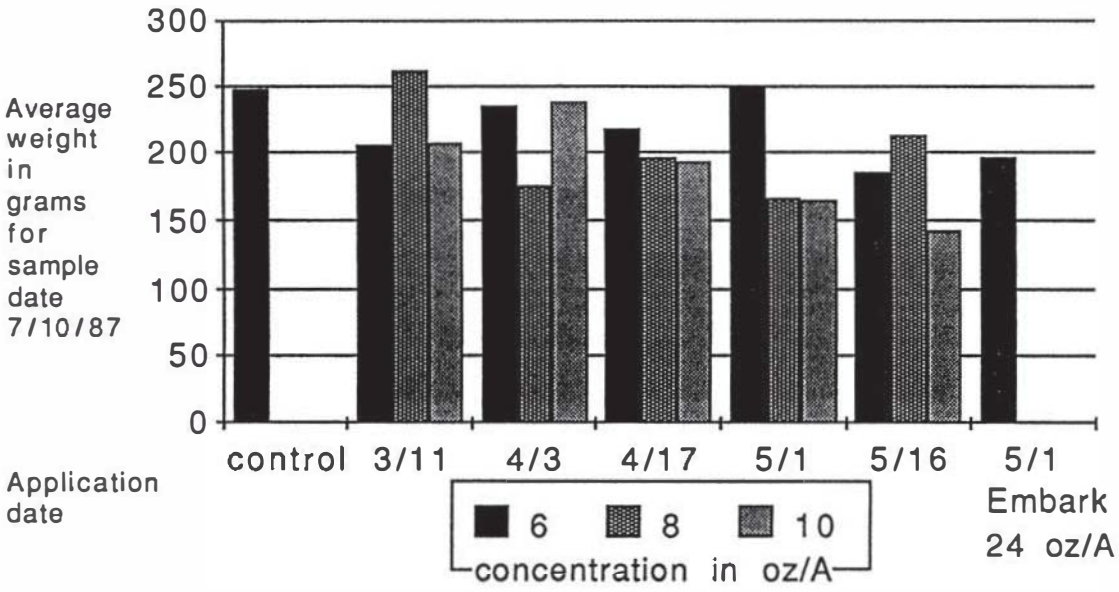
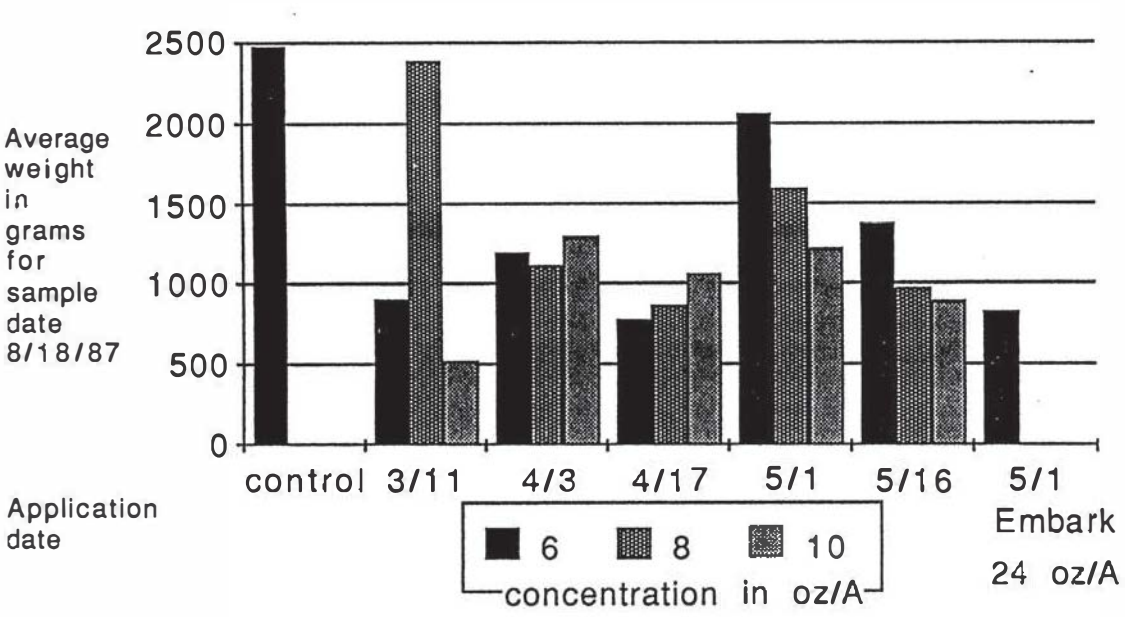


Figure 4 The average weight, in grams, of grass cuttings collected from rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The turf was cut to two inches for a 6 foot by 7.5 foot area of the sample plots. Embark was also applied for a comparison. Samples were collected on August 18, 1987.



cut for the duration of the experiment are listed in Table 5. Application date 4/17 was the most effective for all sample dates. Ten ounces per acre yielded the greatest suppression for five of the six sample dates, 8 oz./A for the sixth.

Figure 5 illustrates the results of sample date 5/14 for the average reduction in height of uncut turf. Ten ounces per acre was the most effective concentration for application dates 3/11 and 4/17, 8 oz./A for 4/3 and 6 oz./A for 5/1. Embark showed no reduction in height for this sample date.

Ten ounces per acre was the most effective concentration for application dates 3/11, 4/3 and 5/1 for sample date 5/21. Eight ounces per acre was most effective for 4/17. For application date 5/16, 6 oz./A was as effective as 8 oz./A (Figure 6). Embark showed little reduction on this date as did the 5/16 application of Event.

For sample date 5/29, 10 oz./A was the most effective concentration of Event for all application dates. All plots treated with Event showed greater reduction in height of uncut turf than Embark (Figure 7).

Sample date 6/11 indicates that 10 oz./A was the most effective concentration for application dates 3/11 and 4/17. Eight ounces per acre was most effective for application dates 4/3 and 5/16; 6 oz./A for application

Table 5. Visual study of the average percent reduction in height of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied as a comparison.

Application date & concentration in ounces/acre	Date of visual study					
	5/14	5/21	5/29	6/11	6/20	7/2
3/11, 6 oz./A	5	10	18	7	2	0
8 oz./A	2	2	5	12	7	5
10 oz./A	42	27	38	27	15	8
4/3, 6 oz./A	8	8	13	17	9	5
8 oz./A	57	33	42	43	27	33
10 oz./A	45	35	47	38	43	30
4/17, 6 oz./A	60	47	57	50	40	45
8 oz./A	85	80	85	63	68	60
10 oz./A	88	75	89	80	82	80
5/1, 6 oz./A	15	20	42	55	27	20
8 oz./A	9	38	42	50	48	22
10 oz./A	10	52	68	43	55	37
5/16, 6 oz./A		2	7	12	0	0
8 oz./A		2	3	28	10	5
10 oz./A		1	8	10	2	0
Embark, 5/1, 24 oz./A	0	2	1	15	8	0

Figure 5 Visual study of the average percent reduction in height of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 14, 1987.

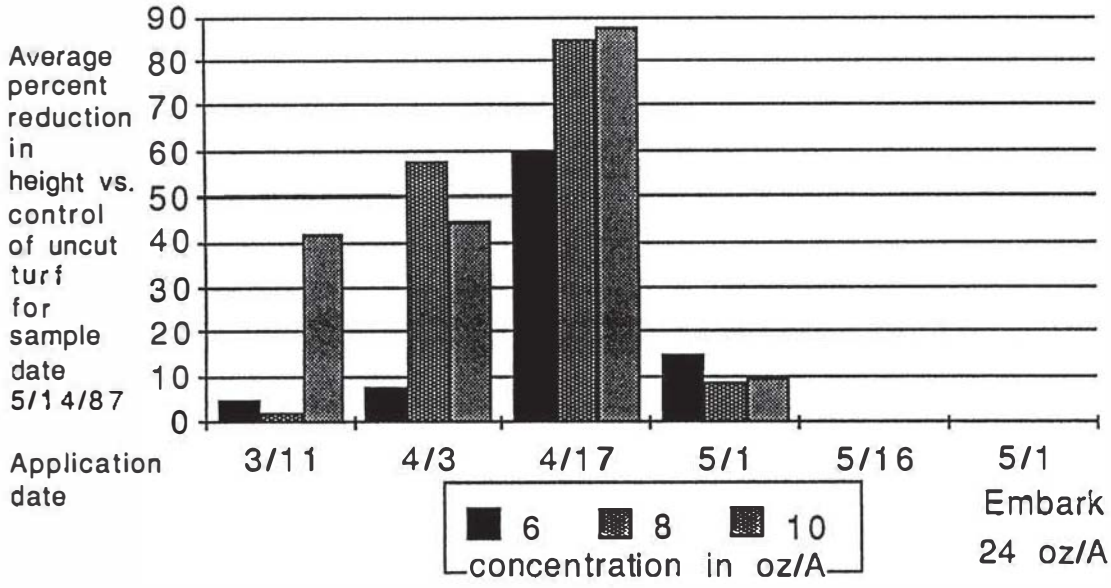


Figure 6 Visual study of the average percent reduction in height of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 21, 1987.

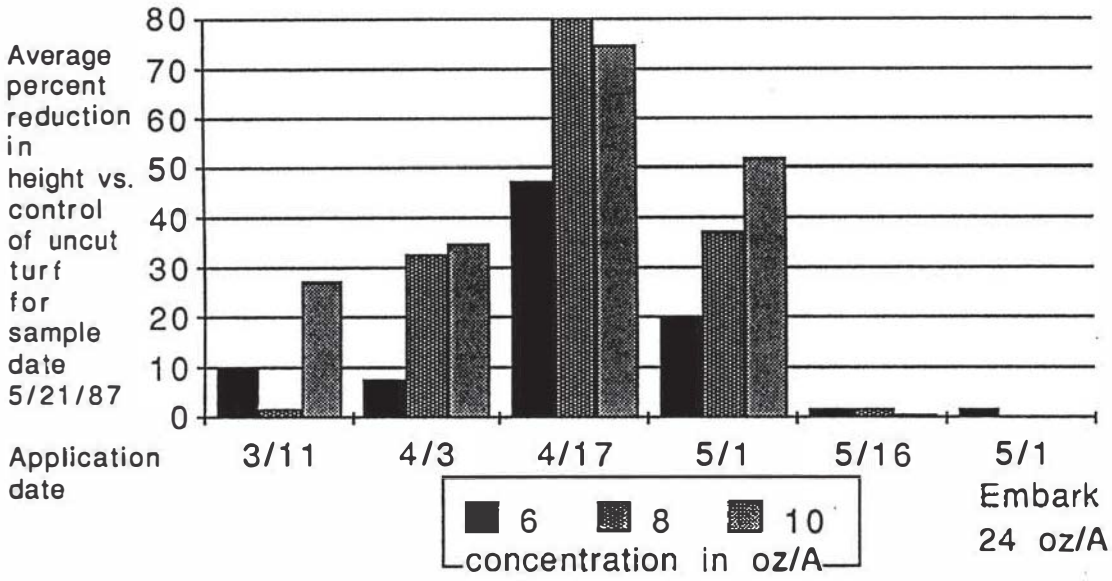
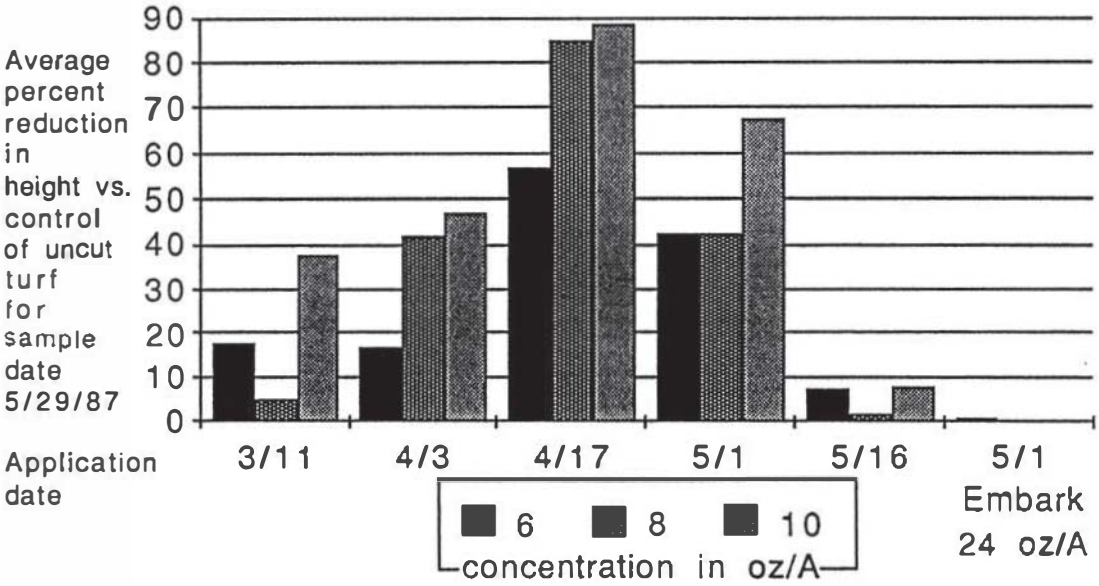


Figure 7

Visual study of the average percent reduction in height of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 29, 1987.



date 5/1. The most effective concentration of Event for each application date was more effective than Embark (Figure 8).

Ten ounces per acre was the most effective concentration of Event for the first four application dates on sample date 6/20 (Figure 9). Eight ounces per acre was more effective for application date 5/16. Six ounces per acre did not prove to be the most effective for any of the application dates of Event. Embark was less effective than Event at the most effective concentration.

The results of the final sample date for visual studies on the average reduction of height of uncut turf from control is listed in Figure 10. Ten ounces per acre of Event proved most effective for application dates 3/11, 4/17 and 5/1. Eight ounces per acre for 4/3 and 5/16. Embark showed no visible reduction from control.

Subjective visual studies on the average percent reduction in height of turf from the plots that were cut to two inches on April 29, 1987 are listed in Table 6.

Figure 11 indicates the average percent reduction in height of cut turf from control for sample date 5/14. Ten ounces per acre was the most effective concentration of Event for application dates 4/17 and 5/1. Eight ounces per acre was most effective for 4/3 and 6 oz./A for 3/11. Overall, application date 4/17 was the most effective date of application. Embark proved more effective than

Figure 8 Visual study of the average percent reduction in height of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 11, 1987.

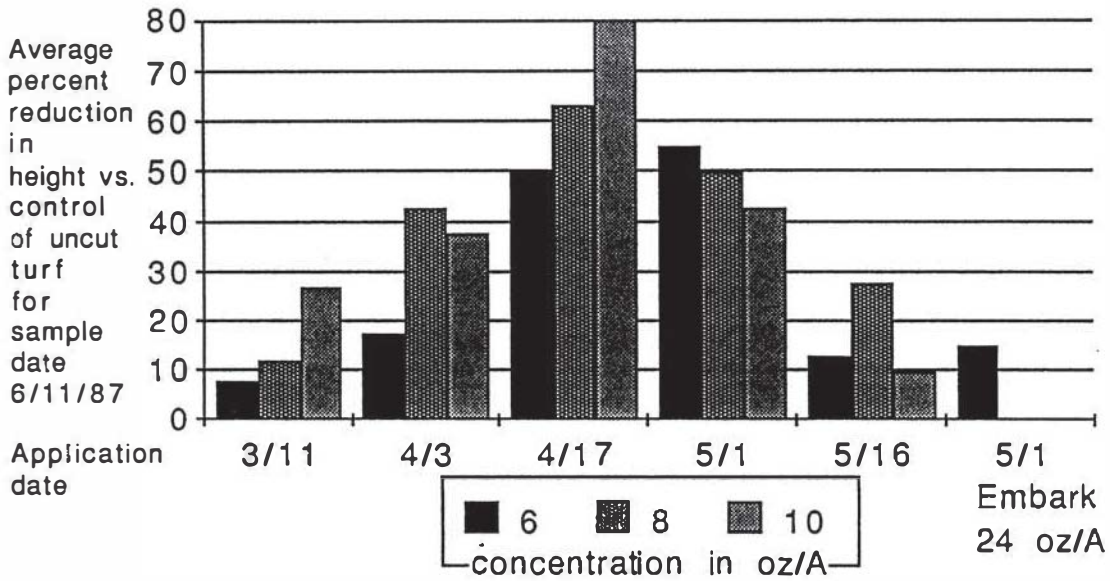


Figure 9 Visual study of the average percent reduction in height of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 20, 1987.

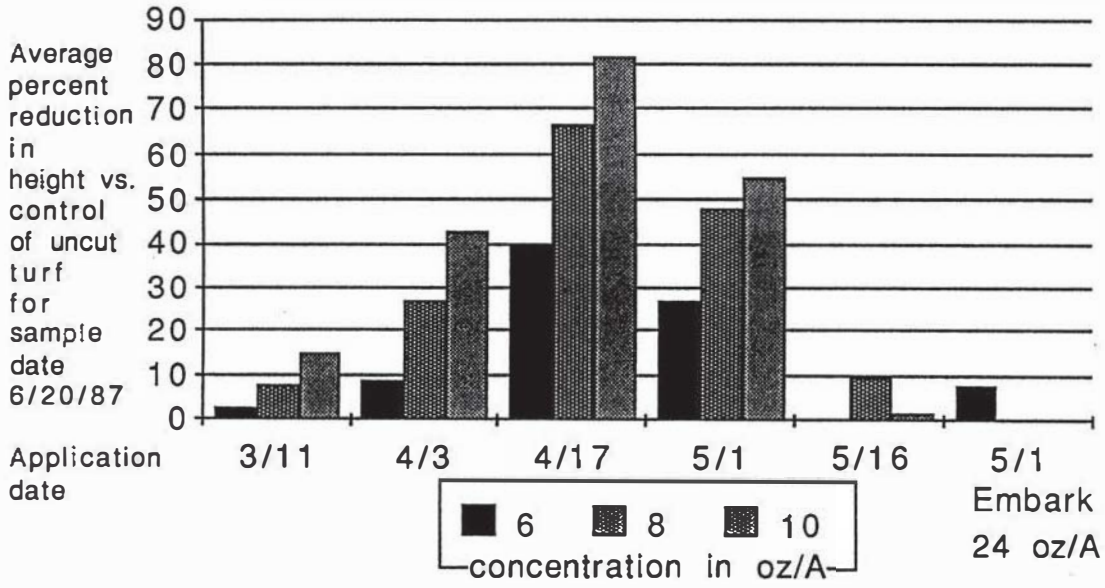


Figure 10 Visual study of the average percent reduction in height of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on July 2, 1987.

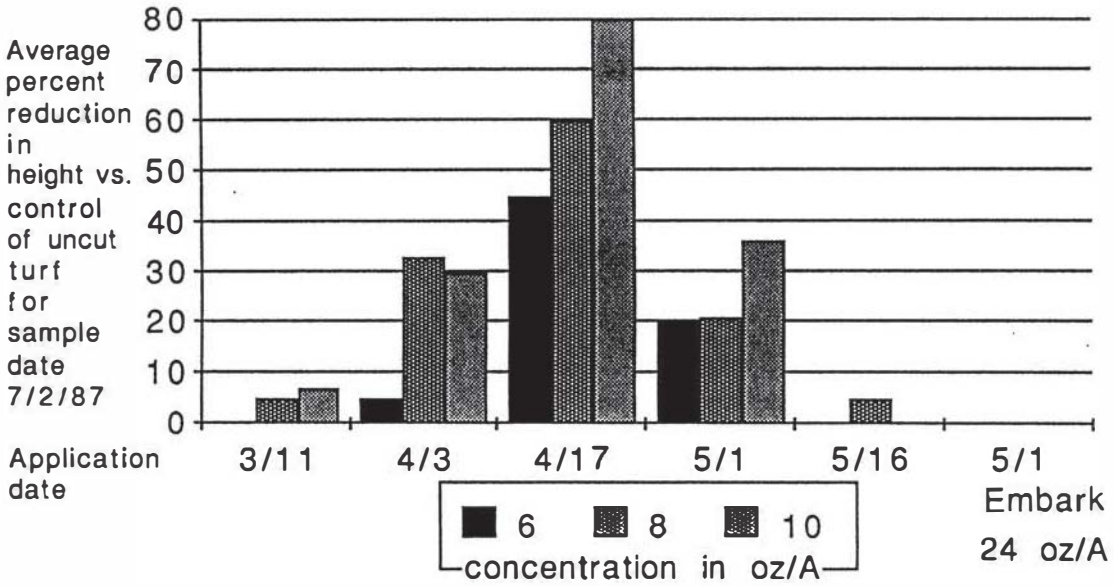
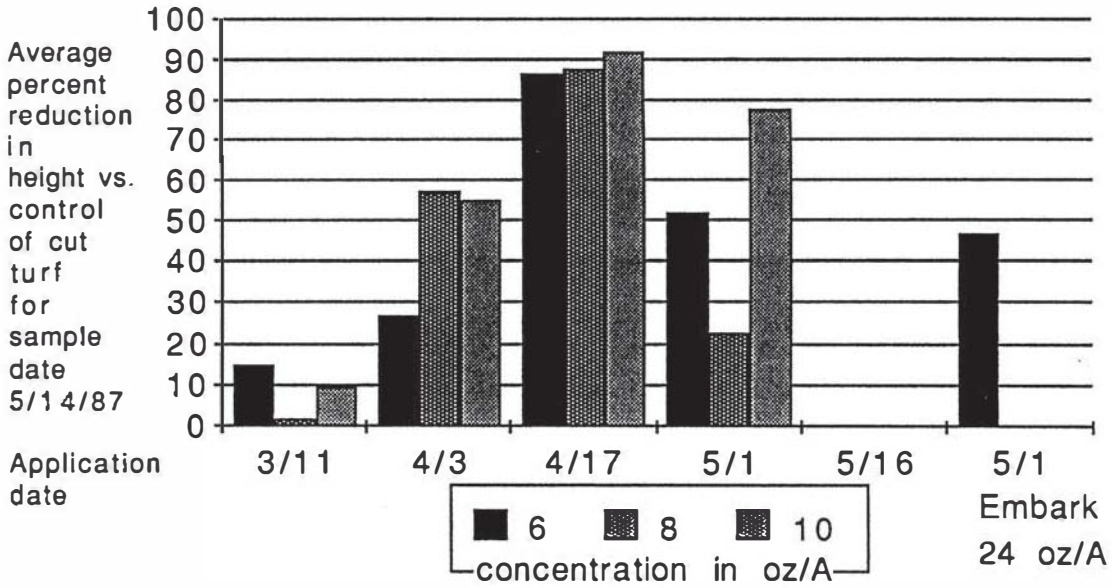


Table 6. Visual study of the average percent reduction in height of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied as a comparison.

Application date & concentration in ounces/acre	Date of visual study					
	5/14	5/21	5/29	6/11	6/20	7/2
3/11, 6 oz./A	15	27	18	10	2	2
8 oz./A	2	2	5	22	7	5
10 oz./A	10	30	42	27	18	10
4/3, 6 oz./A	27	37	42	27	24	17
8 oz./A	57	48	53	37	52	35
10 oz./A	55	62	67	43	60	55
4/17, 6 oz./A	87	65	78	72	52	60
8 oz./A	88	80	83	63	55	70
10 oz./A	92	91	89	80	83	75
5/1, 6 oz./A	52	62	80	70	70	75
8 oz./A	23	75	88	80	88	80
10 oz./A	78	73	95	77	87	82
5/16, 6 oz./A		15	12	14	7	8
8 oz./A		7	17	23	25	5
10 oz./A		12	33	22	27	10
Embark, 5/1, 24 oz./A	47	42	32	33	15	3

Figure 11 Visual study of the average percent reduction in height of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 14, 1987.



application date 3/11, however the other application dates of Event were more effective at their concentration of greatest height reduction.

Sample date 5/21 (Figure 12) shows 10 oz./A most effective for the first three application dates. Eight ounces per acre was most effective for date 5/1 and 6 oz./A for 5/16. Again application date 4/17 proved most effective. Embark showed a greater reduction in height than Event at application dates 3/11 and 5/16. The most effective concentrations of Event for dates 4/3, 4/17 and 5/1 were more effective than Embark.

For sample date 5/29, 10 oz./A was the most effective concentration for all application dates of Event, 5/1 being the most effective date. Embark proved less effective than all 10 oz./A applications of Event (Figure 13).

Ten ounces per acre was the most effective concentration of Event for the first three application dates on sample date 6/11. Eight ounces per acre was most effective for the latter two application dates (Figure 14). Application date 4/17 proved as effective as 5/1 at the most effective concentrations for this sample date; 5/1, however, gave the best total reduction when all concentrations are considered. Embark was more effective than Event for dates 3/11 and 5/16. Event was more effective than Embark for the remaining application dates.

Figure 12 Visual study of the average percent reduction in height of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 21 1987.

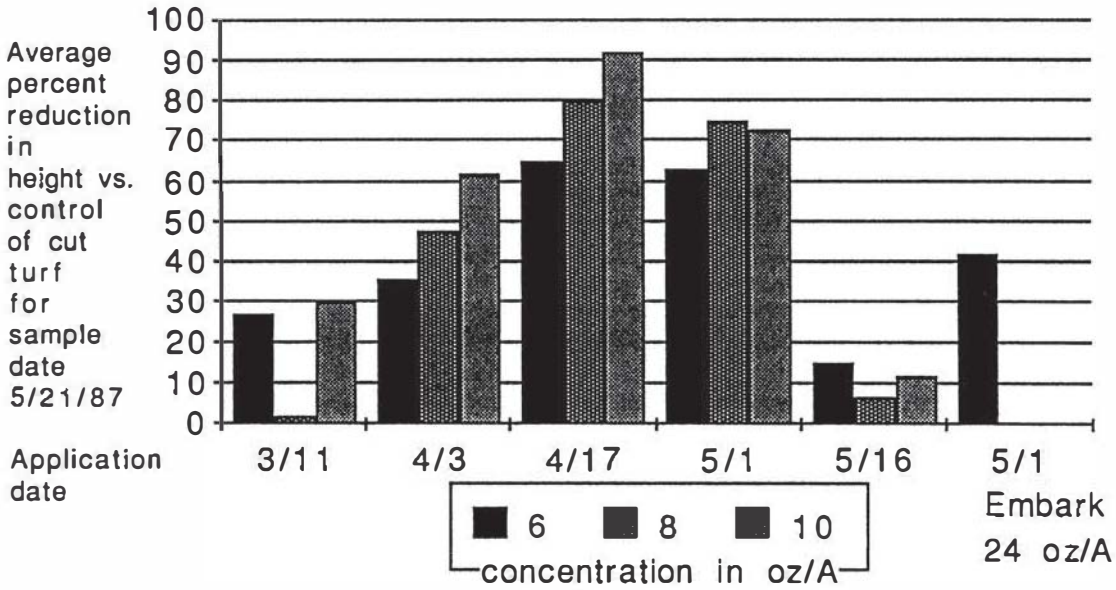


Figure 13 Visual study of the average percent reduction in height of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 29,1987.

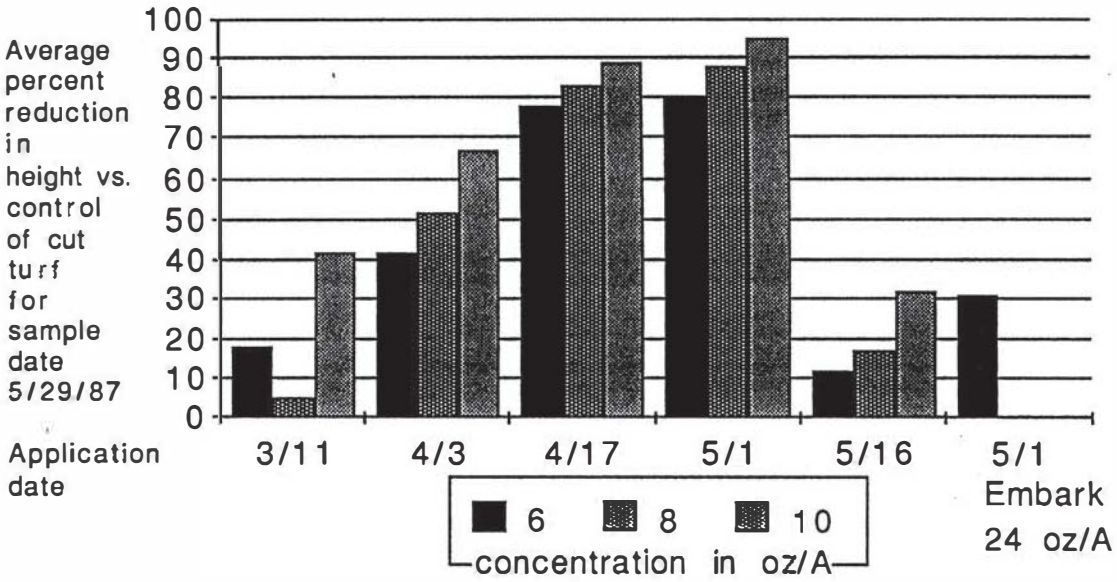
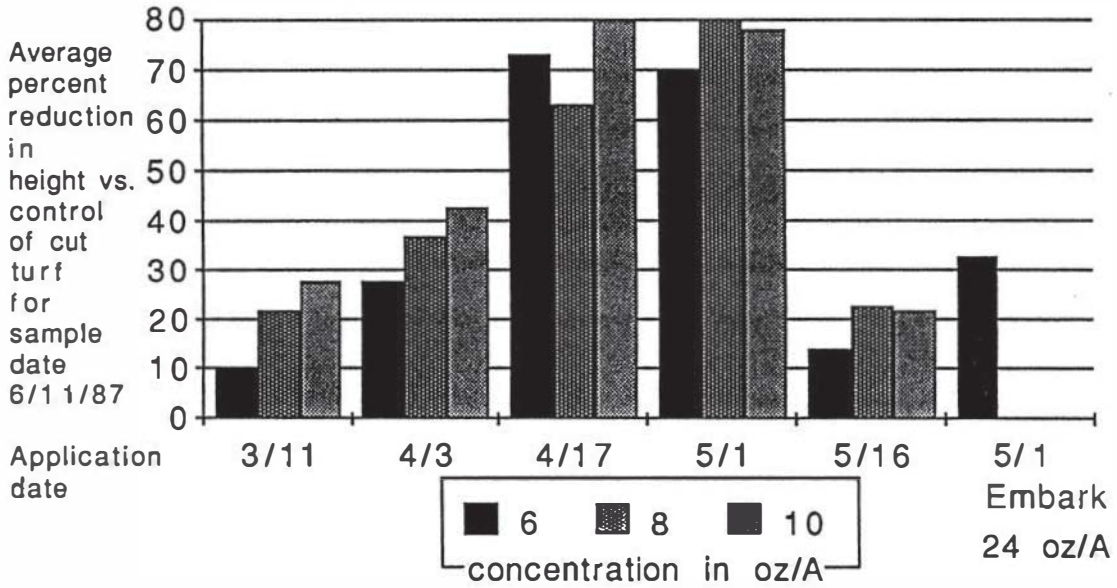


Figure 14 Visual study of the average percent reduction in height of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 11,1987.



Sample date 6/20 (Figure 15) indicated 10 oz./A most effective for the first three application dates and 8 oz./A for the later two, as in the previous sample date. Application date 5/1 showed the greatest reduction. Embark was less effective than the concentration of Event showing the greatest reduction.

Ten ounces per acre was the most effective concentration of Event, on sample date 7/2, for all application dates. Application date 5/1 proved the most effective. Embark was less effective than the most effective concentration of Event for all application dates (Figure 16).

Subjective visual studies on the average percent reduction in seedhead production for subplots that were left uncut for the duration of the experiment are listed in Table 7. Application date 4/17 is the most effective application date for all sample dates.

For sample date 5/14 (Figure 17), 10 oz./A is the most effective concentration of Event for application date 3/11, 8 oz./A for application dates 4/3, 4/17 and 5/1. Embark showed no reduction in seedhead production for this sample date.

Sample date 5/21 indicates that 10 oz./A is most effective for application dates 3/11, 4/17 and 5/1. Eight ounces per acre was most effective for the remaining two

Figure 15 Visual study of the average percent reduction in height of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 20,1987.

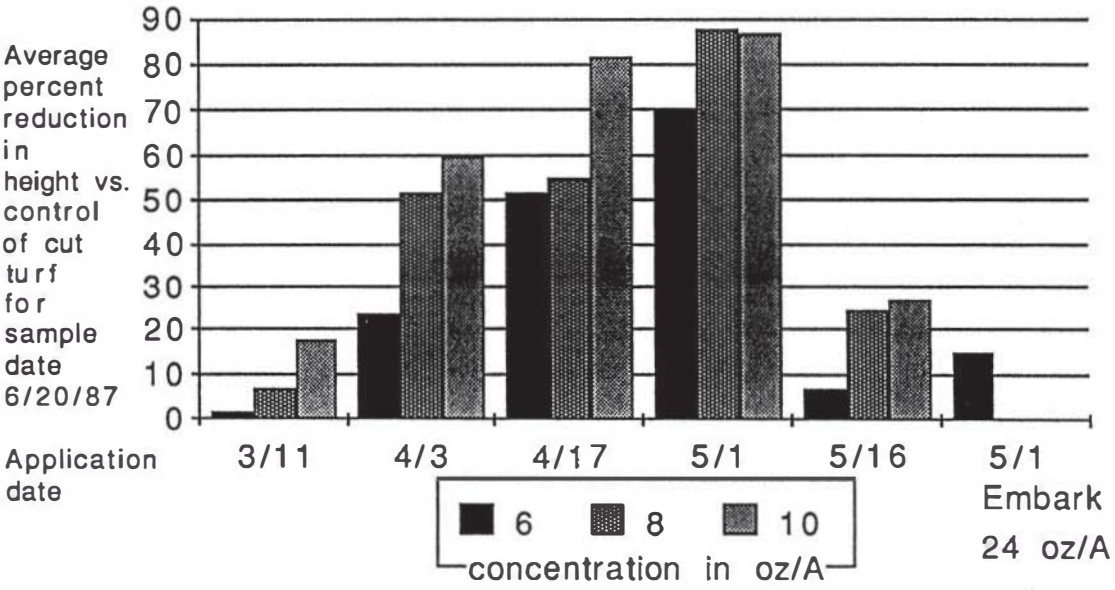


Figure 16 Visual study of the average percent reduction in height of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on July 2,1987.

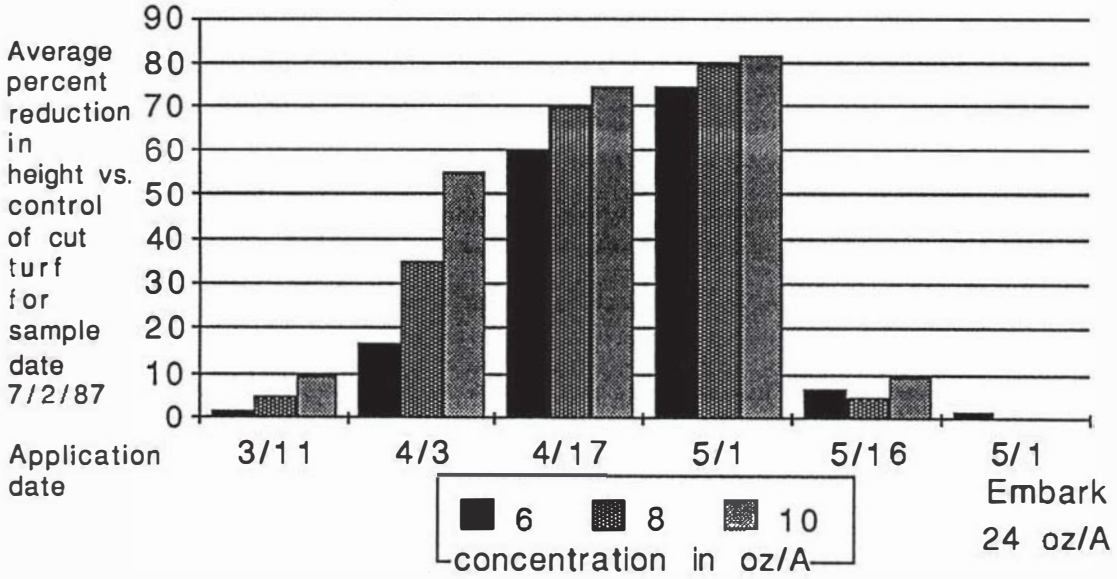
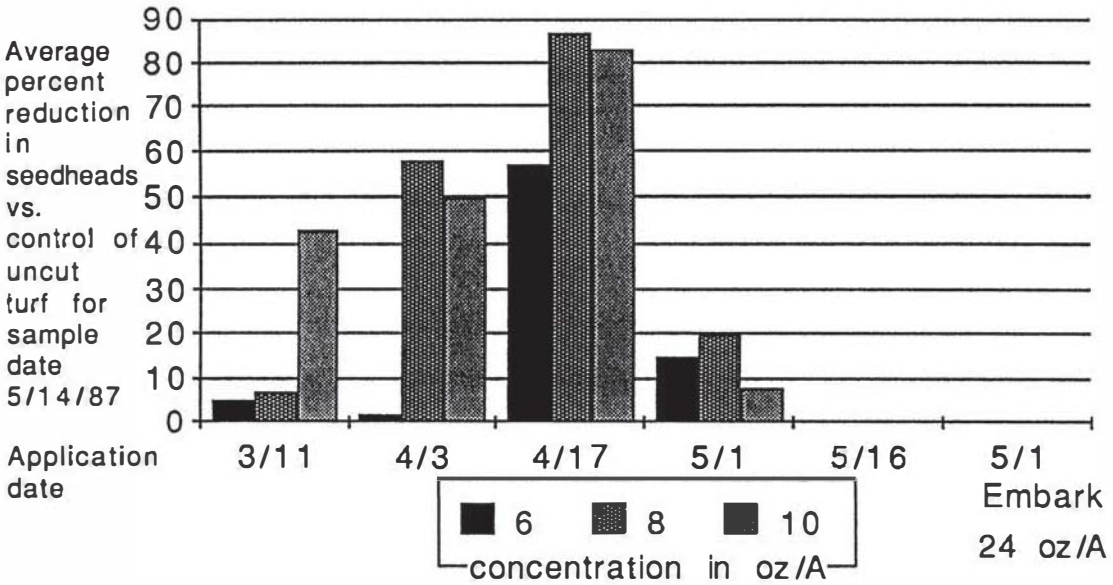


Table 7. Visual study of the average percent reduction in seedheads of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied as a comparison.

Application date & concentration in ounces/acre	Date of visual study				
	5/14	5/21	5/29	6/11	6/20
3/11, 6 oz./A	5	10	14	7	2
8 oz./A	7	2	2	3	7
10 oz./A	43	20	28	15	3
4/3, 6 oz./A	2	10	9	2	4
8 oz./A	58	20	50	13	13
10 oz./A	50	15	37	10	27
4/17, 6 oz./A	57	37	62	33	15
8 oz./A	87	78	85	65	53
10 oz./A	83	80	89	70	67
5/1, 6 oz./A	15	12	12	1	0
8 oz./A	20	7	22	0	5
10 oz./A	8	28	47	17	7
5/16, 6 oz./A		1	5	0	0
8 oz./A		2	0	7	0
10 oz./A		1	1	2	0
Embark, 5/1, 24 oz./A	0	0	7	7	2

Figure 17 Visual study of the average percent reduction in seedheads of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 14, 1987.



application dates. Again, Embark showed no reduction for this sample date (Figure 18).

Figure 19 illustrates the average percent reduction in seedhead production of uncut turf for sample date 5/29. Ten ounces per acre appears most effective for application dates 3/11, 4/17 and 5/1. Application date 4/3 was most effective at 8 oz./A and 5/16 at 6 oz./A. Embark was more effective than Event's 5/16 application date but less effective than the most effective concentrations for the remaining application dates.

Sample date 6/11 (Figure 20) indicates 10 oz./A as most effective for dates 3/11, 4/17 and 5/1, 8 oz./A for 4/3 and 5/16. Embark was as useful as the 5/16 application date but less effective than the other application dates of ACP1911.

Ten ounces per acre proved most effective for application dates 4/3, 4/17 and 5/1, 8 oz./A for application date 3/11 (Figure 21). Embark was less effective than the most productive concentrations for all application dates except for 5/16, which showed no reduction for any concentration for the 6/20 sample date.

Subjective visual studies on the average percent reduction of seedhead production for turf cut to two inches on April 29, 1987 are listed in Table 8. Application date 4/17 of Event was observed to be most effective for all sample dates.

Figure 18 Visual study of the average percent reduction in seedheads of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 21, 1987.

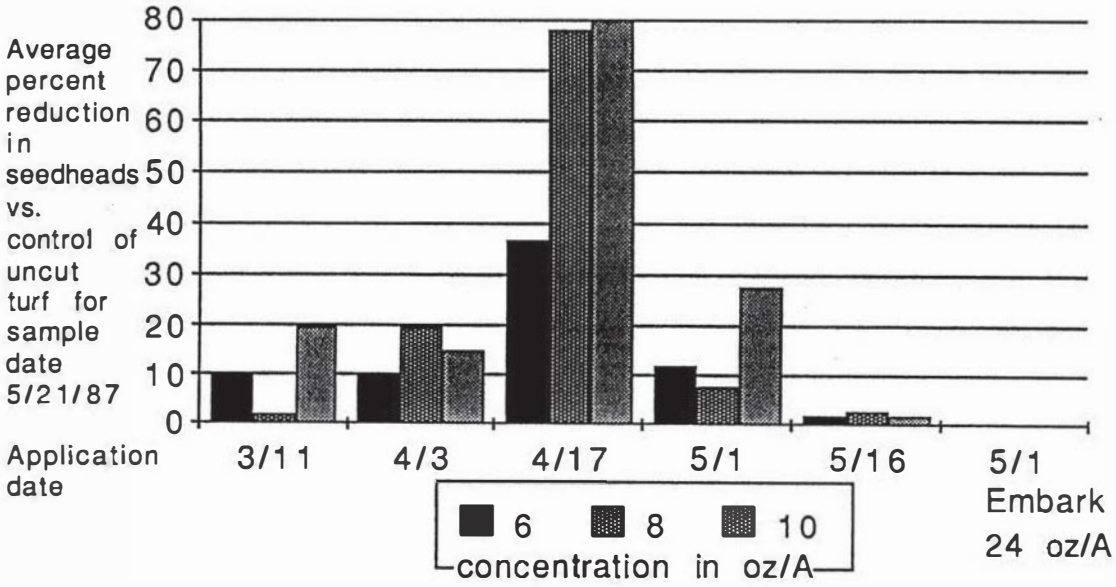


Figure 19 Visual study of the average percent reduction in seedheads of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 29, 1987.

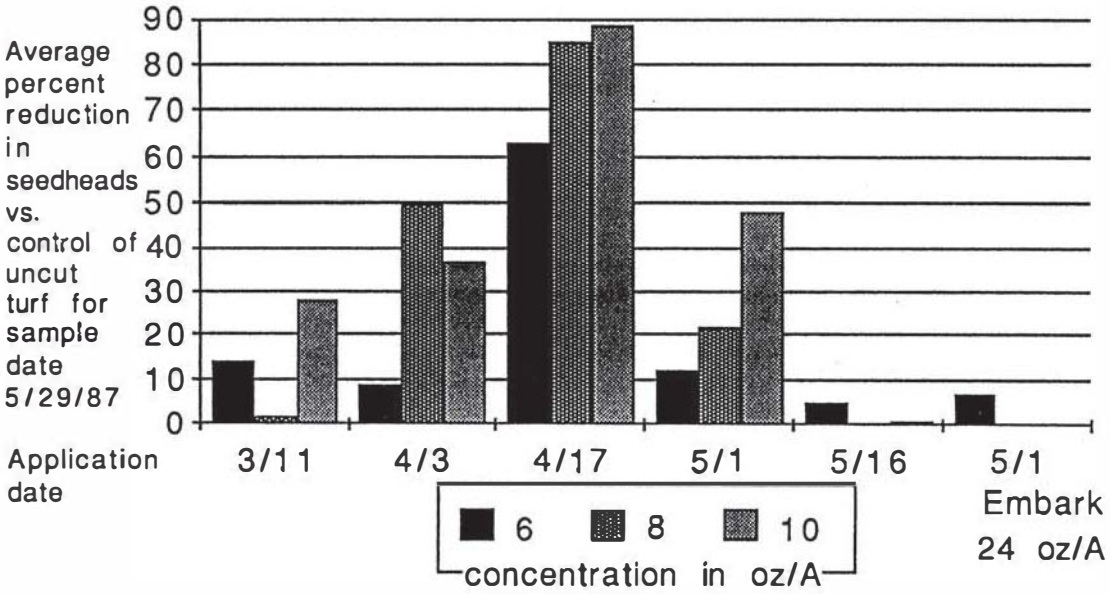


Figure 20 Visual study of the average percent reduction in seedheads of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 11, 1987.

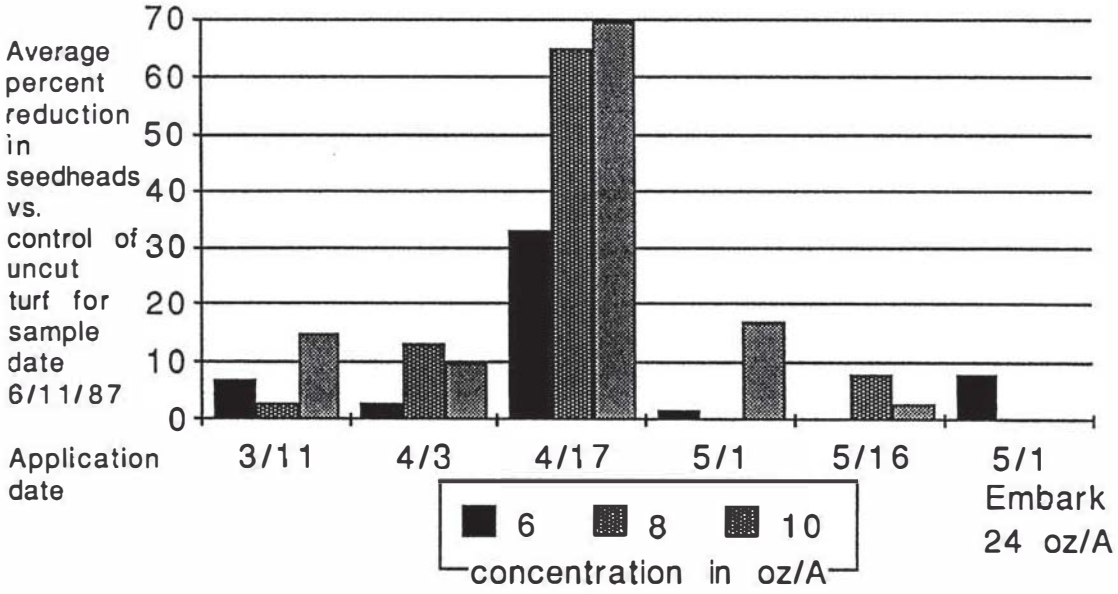


Figure 21 Visual study of the average percent reduction in seedheads of uncut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 20, 1987.

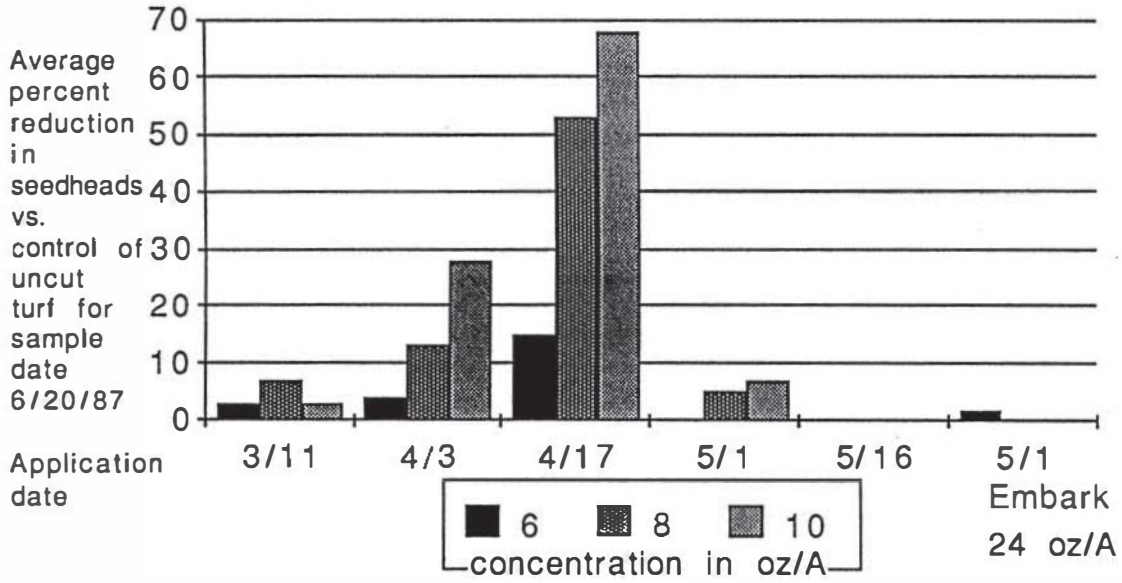


Table 8. Visual study of the average percent reduction in seedheads of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied as a comparison.

Application date & concentration in ounces/acre	Date of visual study				
	5/14	5/21	5/29	6/11	6/20
3/11, 6 oz./A	7	7	14	7	2
8 oz./A	3	2	2	3	5
10 oz./A	20	27	28	15	3
4/3, 6 oz./A	12	22	37	5	7
8 oz./A	65	45	37	15	27
10 oz./A	55	55	80	17	52
4/17, 6 oz./A	70	65	77	20	42
8 oz./A	87	85	85	67	62
10 oz./A	92	87	89	75	57
5/1, 6 oz./A	23	43	65	40	15
8 oz./A	33	65	73	37	25
10 oz./A	90	62	62	43	37
5/16, 6 oz./A		7	7	2	0
8 oz./A		3	12	10	0
10 oz./A		15	23	2	12
Embark, 5/1, 24 oz./A	30	45	30	15	15

Figure 22 illustrates the results of sample date 5/14. Ten ounces per acres was most effective for application dates 3/11, 4/17 and 5/1, 8 oz./A for 4/3. Embark was more effective than the 3/11 application date of Event, all other application dates of Event were more effective at their most effective concentration.

Sample date 5/21 (Figure 23) shows 10 oz./A to be the most effective concentration for application date 3/11, 4/3, 4/17 and 5/16, 8 oz./A for 5/1. Embark was more effective than sample dates 3/11 and 5/16. Event was more effective for the other three application dates when used at the most effective concentration.

Sample date 5/29 (Figure 24) indicates that 10 oz./A was the most effective concentration for all sample dates except 5/1, where 8 oz./A proved more effective. As in the previous sample date, Embark was more effective than the 3/11 and 5/16 application dates of Event and less effective than the 4/3, 4/17 and 5/1 dates.

Figure 25 illustrates the results of sample date 6/11. Ten ounces per acre was the most effective for the first four sample dates, 8 oz./A for 5/16. Embark was more effective at seedhead reduction than application date 5/16, and as effective as 10 oz./A for 3/11. The other application dates of Event were more effective than Embark at their most efficient concentration.

Figure 22 Visual study of the average percent reduction in seedheads of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 14, 1987.

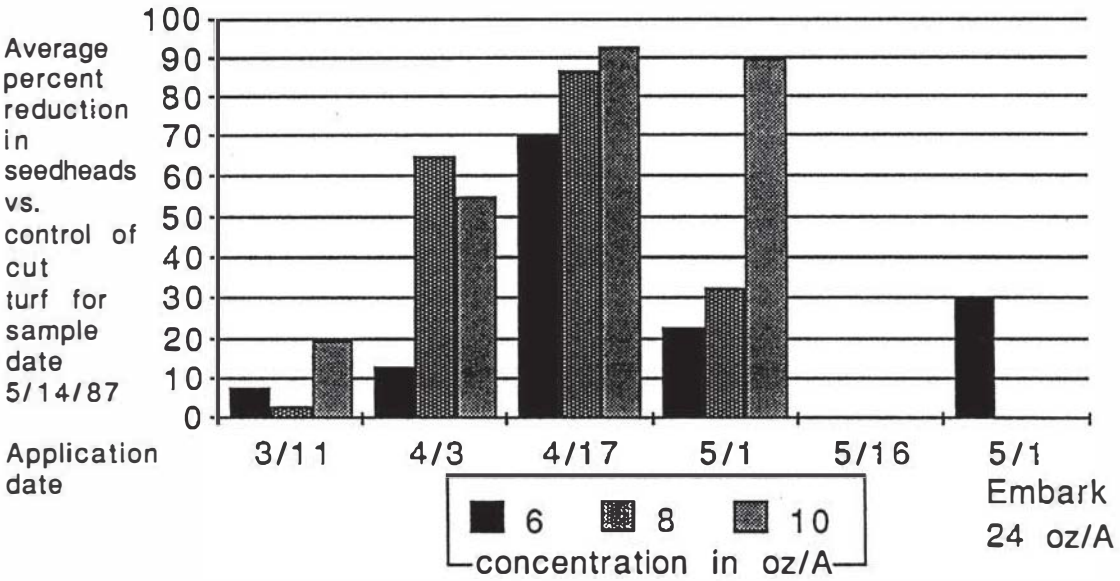


Figure 23 Visual study of the average percent reduction in seedheads of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 21, 1987.

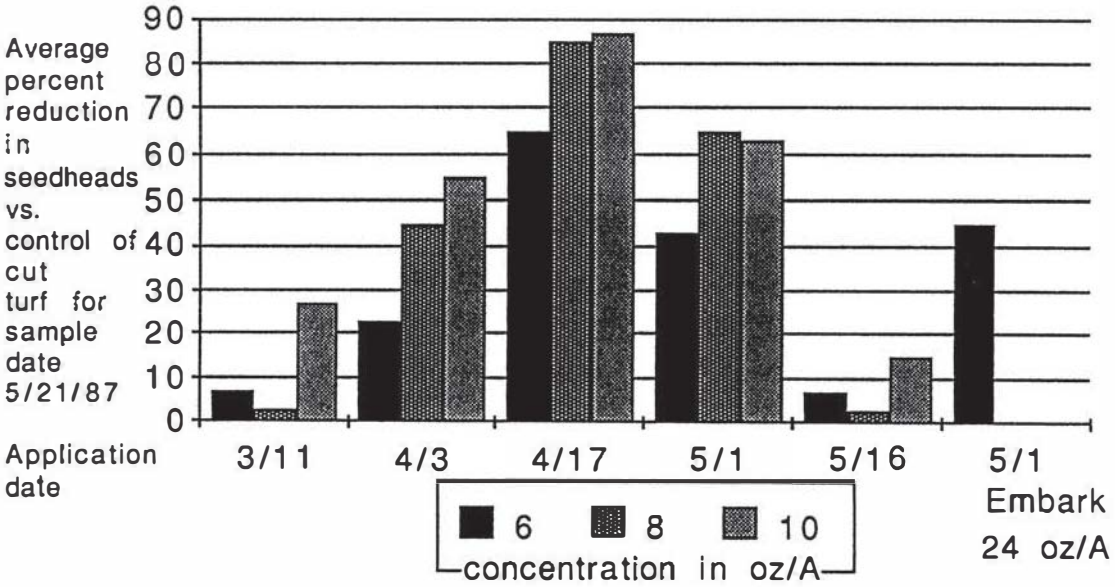


Figure 24 Visual study of the average percent reduction in seedheads of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on May 29, 1987.

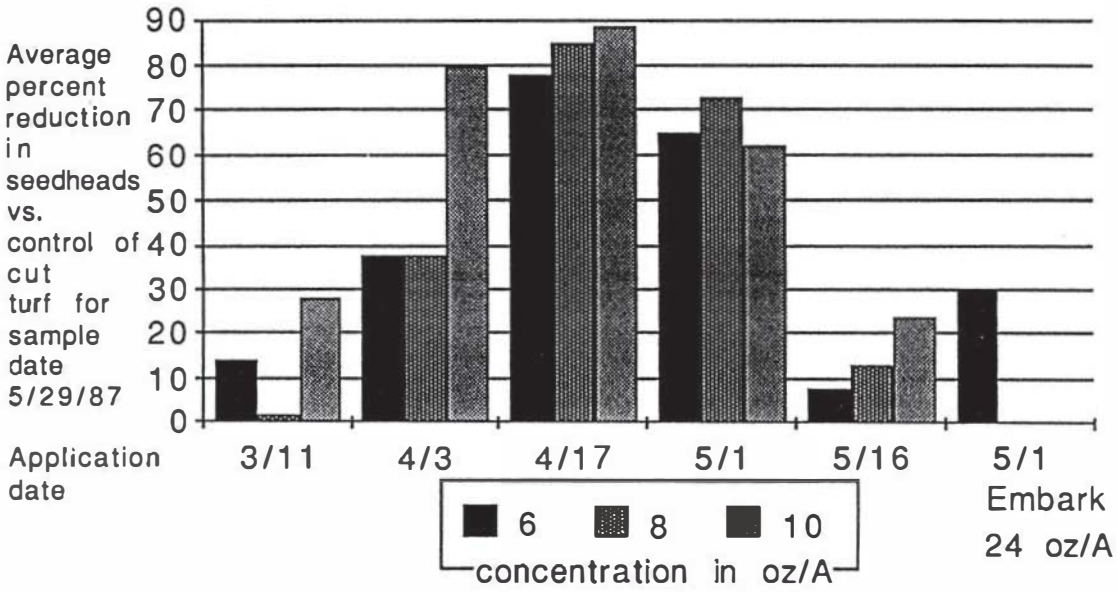
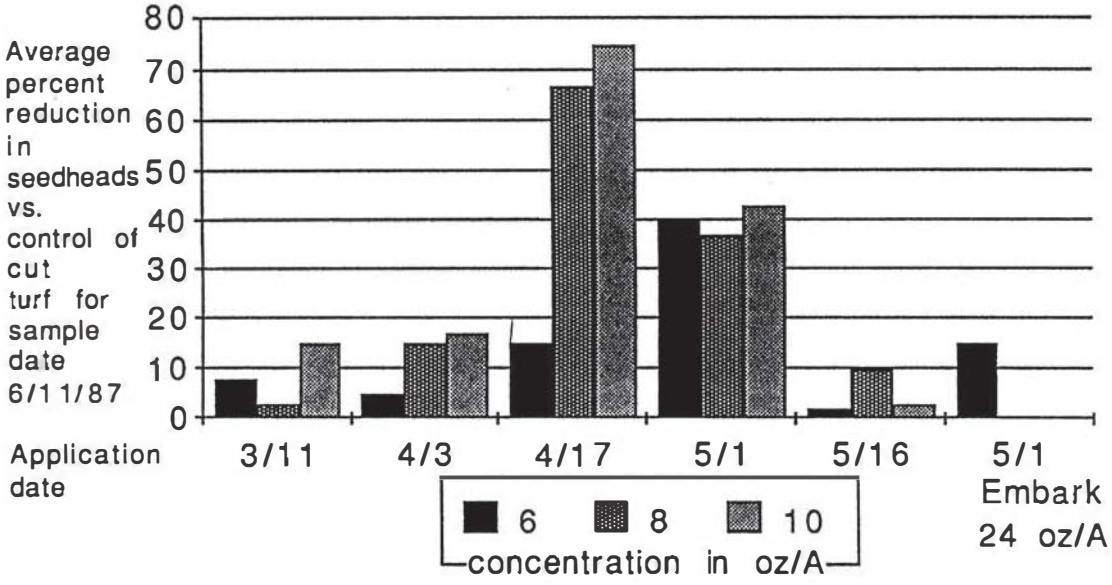


Figure 25 Visual study of the average percent reduction in seedheads of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 11, 1987.



The June 20 sample date (Figure 26) shows that 10 oz./A is the most effective concentration for application dates 4/3, 5/1, 5/16, and 8 oz./A for 3/11 and 5/16. Embark was more effective than the 3/11 and 5/16 applications of Event, the other application dates of Event were more effective than Embark at their most effective concentrations.

Subjective visual studies on weed control were noted on May 29, June 20 and July 2. The extent of weed control was rated on a scale of 1 to 4; 4 indicating little or no difference from control and 1 indicating a very small weed population in comparison to control (Table 9). Event applications sampled on 5/29 showed good weed control for all application dates except 3/11 where little or no weed reduction was noted for concentrations of 6 and 8 oz./A. Application date 4/17 at 10 oz./A seemed most effective. Two of the three repetitions for this rate showed a complete absence of weeds; this is an actual count, not an estimation as indicated in the first column of table 9 for these experiments. Sample date 6/20 shows an overall decrease in weed control from the first sample date. Application date 5/1 at 10 oz./A shows the greatest control, with one repetition with a complete lack of weeds. Application date 5/1 is also most effective for sample date 7/2, all concentrations appear equally as effective for

Figure 26 Visual study of the average percent reduction in seedheads of cut rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The test plots were divided into two areas; an area where the turf was mowed to two inches on April 29, 1987 and an area left uncut. Embark was also applied for a comparison. Visual study taken on June 20, 1987.

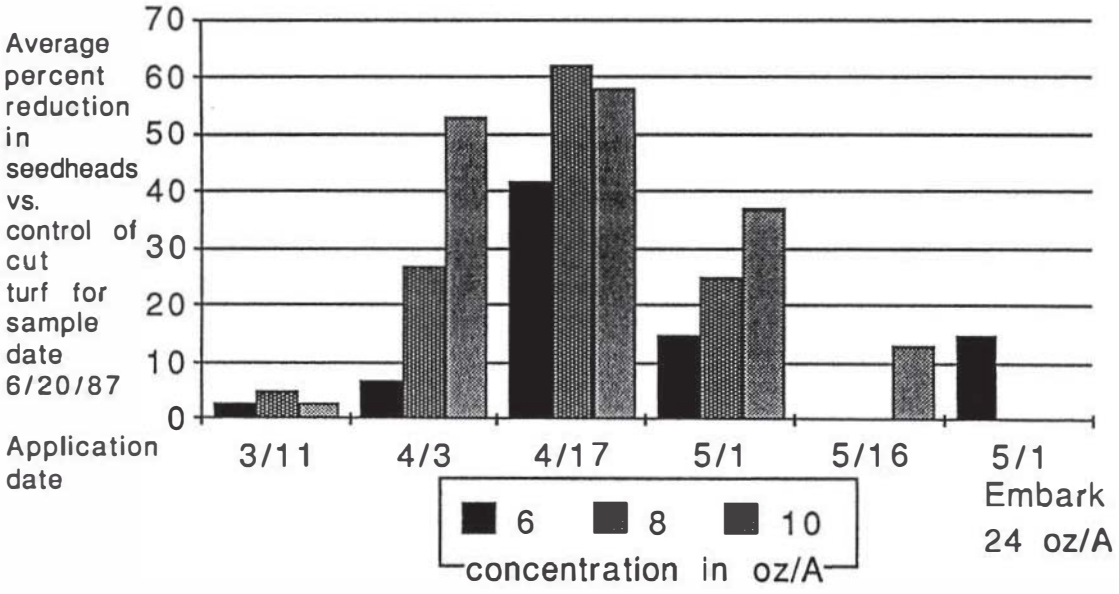


Table 9. Visual study of weed growth on rough turf at Coles County Airport. The turf was treated with plant growth regulator ACP1911 at concentrations of 6, 8 and 10 ounces per acre. The weed growth was estimated on a scale of 1 to 4; 4 indicated little or no weed reduction from control and 1 indicating very few weeds present.

Application date & concentration in ounces/acre	Sample Date 5/29	Reps without weeds present	6/20	Reps without weeds present	7/2	Reps without weeds present
3/11, 6	4	0	3	0	4	0
8	4	0	3	0	4	0
10	1	1	1	0	4	0
4/3, 6	1	1	1	0	4	0
8	2	0	3	0	3	0
10	1	1	1	0	2	0
4/17, 6	2	0	2	0	3	0
8	1	1	3	0	3	0
10	1	2	2	0	2	0
5/1, 6	1	1	3	0	2	0
8	1	1	1	0	2	0
10	1	1	1	1	2	0
5/16, 6	2	1	1	0	3	0
8	2	0	4	0	3	0
10	2	0	4	0	3	0
Embark, 5/1, 24	1	0	3	0	3	0

this sample date. No repetitions at any date of application or concentration had a complete lack of weeds.

Observation of test plots noted no extensive change in grass color compared to control as a result of the plant growth regulators. These observations were noted from May 14 until termination of the experiment.

There was little apparent injury to the turf noted during the visual studies. No injury was noted for the first application date, March 11. Injury was noted on May 29 in one repetition from the second application date (April 3), at 6 oz./A and at 8 oz./A. The injury consisted of an uneven growth pattern giving the turf a "spotty" appearance. This same type of injury was also noted on May 29 for one repetition at 6 oz./A for the 4/17 application date, 6 oz./A for the 5/1 application date and 8 oz./A for the 5/16 application date. The same type of injury was noted, on the same observation date, for two repetitions at 10 oz./A for the 5/16 application date. One repetition of Embark showed similar injury on May 29, June 10 and 20. No other injury to the turf was noted during visual studies.

Several test plots showed a marked inconsistency in plant growth. There were four strips of high turf reduction spaced between areas of little turf reduction. These lines ran parallel to the application route and were spaced such that application error, with the hand held unit, seemed a logical conclusion. There did not seem to

be greater injury to turf in these areas. Weed production was more limited in areas of suppressed turf growth. This banding into areas of high and low plant growth reduction was taken into account for the visual studies.

Discussion

For the most part, information from the visual studies correlates well with that from the weight studies. Application date 4/17 for the first two sample dates and application date 5/1 for the later sample dates show greatest reduction in the height of cut turf. A similar change was seen in weight studies with later application dates becoming more effective as time passed. For studies with uncut turf 4/17 appears to be the most effective at height reduction, however in almost all cases the cut turf showed superior reduction to the uncut. Elkins and Temmen (1985, 1986), Bhowmik (1985) and Pennucci and Jagschitz (1985) cut the turf shortly before or after the initiation of their experiments.

Duel, Katz and Sherman (1987) found that imazapyr, alone and in combination with imazethapyr, controlled growth as well as mefluidide. Elkins and Temmen (1986) studying the effects of imazethapyr, alone and in combination with imazapyr, collected dry weight samples sixty-two days after treatment on April 29, 1986. They found dry matter yields 33 to 59% reduction from control compared to 41% for Embark. This would correspond most closely to this researchers 5/1 application date and 7/10 sample date where 0 - 42% weight reduction was recorded for Event and 22% for Embark. In the same experiment (Elkins and Temmen, 1986) the height of turf was measured at 7, 15,

20, 35, 42 and 54 days after treatment for an April 17, 1986 application date. All treatments showed a significant reduction from control at 7, 15 and 20 days after treatment and the higher concentrations indicated significant reduction from control for 35, 42 and 54 days after treatment. All samples of imazethapyr alone or with imazapyr showed greater reduction in height than Embark. For Elkins and Temmen (1986), turf height was determined 8, 23, 30, 42 and 58 days after treatment for their April 29 application date. The first two sample dates showed a greater height reduction for the imidizolinone compounds than for Embark. Significant growth control was found through 30 days for imidizolinones with a few concentrations indicating significantly shorter turf than was observed for Embark, the best reducing height 50%. In the present study, this researcher found Event, at its most efficient concentration and application date, to be superior to Embark at the reduction of height from control at all sample dates.

In studies with the similar plant growth regulators, ACP1900, ACP1910, ACP1920, ACP1930 and ACP1940, various results were recorded for height and weight reduction from control and also in comparisons with Embark.

Pennucci and Jagshitz (1985) noted ACP1900 was "not effective" at height reduction of turf. Duel and Neary (1986) indicated ACP1900 was ". . . not sufficient to be

comparable to commercial standards" at height reduction of turf. Bhowmik (1985) indicated that ACP1900 was not as effective as mefluidide at height or weight sample reduction. Prinster and Watschke (1986) indicated that ACP1900 reduced growth to a greater degree than mefluidide, ACP1910, ACP1920, ACP1930 and ACP1940. Elkins and Temmen (1985) indicate ACP1900, ACP1920 AND ACP1930 significantly more effective than Embark at height reduction after 21 days or 28 days (May 9, 1985 and April 25, 1985 application dates respectively).

Data reported in the literature on seedhead reduction from control for imidizolinones proved as variable as reduction of height and weight. Pennucci and Jagshitz (1985) as well as Duel and Neary (1986) indicated ACP1900 was ineffective at seedhead control. Bhowmik (1985) indicated ACP1900 was not as effective as mefluidide. Prinster and Watschke (1986) indicate ACP1900, ACP1910, ACP1920, ACP1930 and ACP1940 were all more effective than mefluidide and all, including mefluidide, were acceptable. Elkins and Temmen (1985) indicated, for the April 25 application date, that ACP1900, ACP1910, ACP1920 and ACP1930 are very effective at seedhead control, when compared to Embark, 28 days after treatment. Elkins and Temmen (1986), in studies with imazethapyr alone and in combination with imazapyr, found Embark less effective. For their April 17 sample date, imidizolinones were more

effective for 20 days after treatment. For their April 29 sample date, imidizolinones yielded no seedheads to 23 days after treatment, Embark reduced seedhead numbers and size. Duel, Katz and Sherman (1987) studied the effects of imazapyr alone and in combination with imazethapyr and found seedhead control comparable to that of mefluidide.

When used at its most effective application date of 4/17 and most effective concentration of 10 oz./A, or in some cases 8 oz./A, this researcher found Event more effective than Embark at seedhead reduction.

Injury to turf or color change of turf by imidizolinones was noted in the literature. Elkins and Temmen (1985 and 1986) noted phytotoxicity and color change due to plant growth regulator application. Early in their experiments these factors were at unacceptable levels but the turf recovered to acceptable levels by 32 to 58 days after treatment. Duel, Katz and Sherman (1987) also noted discoloration similar to that caused by mefluidide for imazapyr and imazethapyr. Prinster and Watschke (1986) noted ACP1910 and ACP1920 caused injury to turf but recovered within thirty-five days after treatment.

No color loss or extensive injury was noted by the researcher for Event. The quick recovery time of turf to imidizolinones may have masked any such injury.

Conclusions

Event, when used at its most effective concentration and applied at its most effective application date, is superior to Embark at the reduction of plant growth in rough turf at Coles County Airport, Illinois. Ten ounces per acre is the most effective concentration although 8 oz./A works well in many cases. Application date April 17, approximately 80% greenup in this study, proved most effective at seedhead reduction and early growth suppression of turf.

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