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DEPARTMENT OF TRANSPORTATION

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RESEARCH REPORT
FIFTH YEAR REPORT

THE PENNSYLVANIA STATE UNIVERSITY
RESEARCH PROJECT # 85-08
REPORT # PA 91-4620 + 85-08

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We wish a fond farewell to Greg Lyman, who left the project in February, 1991, after six years of tireless service. He will be sorely missed by everyone, except perhaps by the word processors's spell-checker.

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INTRODUCTION

In October, 1985, personnel at The Pennsylvania State University began a cooperative research project with the Pennsylvania Department of Transportation to investigate several aspects of roadside vegetation management. An annual report has been submitted each year which describes the research activities and presents the data. The previous reports can be obtained from The National Technical Information Service, Springfield, VA, and are listed below:

Report # PA86-018 + 85-08 - Roadside Vegetation Management Research Report

Report # PA87-021 + 85-08 - Roadside Vegetation Management Research Report
- Second Year Report

Report # PA89-005 + 85-08 - Roadside Vegetation Management Research Report
- Third Year Report

Report # PA90-4620 + 85-08 - Roadside Vegetation Management Research Report
- Fourth Year Report

This report includes information from studies relating to roadside brush control, plant growth regulator applications to roadside turf, evaluation of low maintenance grasses, and total vegetation control for guiderails and signposts. Project activities intended for demonstration purposes such as those at the 1990 Roadside Vegetation Management Conference in Lancaster are not reported.

Herbicides are referred to as product names for ease of reading. The herbicides used in each research area are listed at the beginning of each section by product name, active ingredients, formulation, and manufacturer.

BRUSH CONTROL RESEARCH

Two studies relating to roadside brush control were completed during 1990:

1. Response of Three Grass Species to Fall Applied Brush Control Treatments - brush control herbicides and adjuvants were applied to tall, hard, and creeping red fescues to determine if these materials were injurious to turf.
2. Control of Ash and Birch with Basal Bark Applications Using Several Diluents - two herbicide concentrations in five different diluents were compared for their ability to control stems of ash and birch.

Table 1 lists the trade names, active ingredients, formulation, and manufacturers of brush control materials used for 1990 research.

TABLE 1: Trade name, active ingredient, formulation, and manufacturer of chemicals used during 1990 brush control research.

Product	Active Ingredient	Formulation	Manufacturer
Arsenal	imazapyr	2 S	American Cyanimid Company
Basal Oil	diluent		Arborchem Products, Inc.
CideKick	adjuvant		JLB International Chemical Co.
Clean Cut plus Pine	adjuvant		Arborchem Products, Inc.
Escort	metsulfuron methyl	60 DF	E.I. du Pont de Nemours & Co.
Garlon 4	triclopyr	4 EC	DowElanco
Krenite S	fosamine ammonium	4 S	E.I. du Pont de Nemours & Co.
Penetrator	adjuvant		Helena Chemical Co.
RiteWay	diluent		N.G. Gilbert Corporation
SoyDex	adjuvant		Helena Chemical Co.

Response of Three Grass Species to Fall Applied Brush Control Treatments

Injury to understory grasses from fall applied brush control treatments has been a major concern to Pennsylvania roadside managers. An experiment was conducted to compare the effects of several brush control treatments on tall fescue (Festuca arundinacea), creeping red fescue (Festuca rubra var. rubra.), and hard fescue (Festuca longifolia) (Table 2). Krenite S at 8 qt/acre was applied alone and in combination with Cidekick at three carrier volumes to simulate different application equipment. They were 30 GPA, 60 GPA, and 90 GPA. Other treatments included Cidekick and Clean Cut plus Pine alone, Arsenal, Garlon 4, and Escort alone, and in combination with Krenite S. Plots were 4 by 6 ft, arranged in a randomized complete block design for each species. Treatments were applied on September 7, 1989 with a CO_2 pressurized test plot sprayer and two 8004E flat fan nozzles spraying the same swath. Temperatures of the air, soil surface, and soil at 8 cm was 30°C, 28°C, and 24°C respectively. On May 31, 1990, the treatments were rated for injury on a scale of 1-10 with 1 indicating green vigorous turf, 10 indicating dead turf, and 5 the highest acceptable injury rating for roadside turf. Treatments were rated on October 7, 1990 for percent cover.

TABLE 2: Visual ratings of turf injury on May 31, and percent cover on October 7, 1990 for hard fescue, red fescue, and tall fescue treated September 7, 1989. Injury ratings were on a scale from 1-10 with 1 indicating no injury, 10 indicating dead turf, and 6 unacceptable for roadside turf.

		Hard Fescue		Red Fescue		Tall Fescue	
	Application	5/31	10/7	5/31	10/7	5/31	10/7
Treatment [GPA]	Rate	Injury	Cover	Injury	Cover	Injury	Cover
	(product/acre)	(1-10)	(%)	(1-10)	(%)	(1-10)	(%)
Krenite S [30]	8 qt	7.7	41	3.3	97	3.3	100
Krenite S [60]	8 qt	6.0	77	3.0	100	4.0	100
Krenite S [90]	8 qt	5.7	93	6.0	100	4.0	100
Krenite S [30] Cidekick	8 qt 0.25% (v/v)	5.3	57	2.3	80	2.3	100
Krenite S [60] Cidekick	8 qt 0.25% (v/v)	7.3	60	3.7	100	2.3	97
Krenite S [90] Cidekick	8 qt 0.25% (v/v)	6.7	73	4.7	97	2.7	100
Arsenal [60][1/]	2 oz	4.7	100	4.7	97	2.7	100
Arsenal	4 oz	6.3	90	3.0	100	4.7	100
Arsenal	6 oz	9.0	50	5.3	93	6.0	100
Escort	0.5 oz	2.3	97	2.3	100	2.0	100
Escort	1 oz	2.0	100	2.0	100	4.0	93
Garlon 4	4 qt	2.3	97	1.3	100	2.3	97
Krenite S Arsenal	6 qt 2 oz	6.7	80	3.7	97	3.7	100
Krenite S Arsenal	6 qt 4 oz	7.0	33	5.7	77	7.0	77
Krenite S Escort	6 qt 1 oz	3.3	93	4.7	100	2.0	100
Krenite S Garlon 4	6 qt 0.5 qt	5.0	77	4.3	100	1.3	97
Knenite S Arsenal Escort	6 qt 2 oz 1 oz	8.3	67	5.0	100	8.3	77

Krenite S Garlon 4 Escort	6 qt 0.5 qt 0.5 oz	3.0	93	2.0	100	1.3	100
CideKick	0.50% v/v	2.7	73	2.7	87	2.0	100
Clean Cut plus Pine	0.50% v/v	4.0	100	3.3	97	4.0	100
L.S.D.(P=0.05)		2.6	32	2.5	19	2.4	15

1/ All remaining treatments were applied at 60 GPA.

Hard fescue displayed a higher level of injury on May 31 than red fescue or tall fescue. Unacceptable injury to hard fescue was caused by Krenite S alone or with Cidekick (Table 2). Injury from Arsenal at 2 oz/acre was considered barely acceptable, but the other treatments containing Arsenal caused moderate to severe injury. Treatments containing Escort, Garlon 4, or Cidekick caused little injury. Clean Cut plus Pine caused higher injury ratings than Cidekick, but the treatments were not significantly different. On October 7, plots treated with Krenite S alone, Krenite S with Cidekick in 30 or 60 GPA, Arsenal at 6 oz/acre, and Krenite S plus Arsenal at 4 oz/acre were rated at less than 60 percent cover All other test plots had cover ranging from 67-100% cover and were considered satisfactory for roadsides.

On May 31, the only creeping red fescue plots receiving an injury rating of 5 or more were those treated with Krenite S in 90 GPA, Arsenal at 6 oz/acre, Krenite S plus Arsenal at 4 oz/acre, and Krenite S plus Arsenal and Escort at 2 and 1 oz/acre, respectively. None of the other treatments were considered unacceptable. On October 7, all treatments provided 87-100% cover except Krenite S plus Arsenal at 2 oz/acre and Krenite S plus Cidekick in 30 GPA, which produced 77% and 80% cover, respectively. These were significantly lower than most of the other treatments.

Of the tall fescue plots rated in May, the only treatments that caused injury that could be considered unacceptable were Arsenal at 6 oz/acre, Krenite S plus Arsenal at 4 oz/acre, and Krenite S plus Arsenal plus Escort. In October, all treated areas had 93% cover or better except those treated with Krenite S plus Arsenal at 4 oz/acre or Krenite S plus Arsenal plus Escort. Each provided 77% cover, which though adequate for roadsides, was significantly lower than all other treatments.

Roadside managers should be aware that these grass species have different tolerances of the fall brush treatments evaluated in this study. While the Krenite S treatments applied in different carrier volumes had little effect on the final cover provided by tall or red fescue, Krenite S at low carrier volumes did reduce hard fescue cover. The addition of Cidekick to Krenite S did not seem to be detrimental to any of species. Cidekick or Clean Cut plus Pine applied alone had little effect on any of the species. Arsenal at 6 oz/acre reduced the final hard fescue cover, but not the cover of red or tall fescue. Krenite S plus Arsenal at 4 oz/acre reduced the final cover ratings of all the species, but hard fescue was the most severely affected. The combination of Krenite S plus Arsenal plus Escort caused a reduction in the cover ratings of tall and hard fescue, but creeping red fescue was not as badly affected.

Control of Ash and Birch with Basal Bark Applications Using Several Diluents

In recent years, several diluents have become available for use in basal bark applications as an alternative to diesel fuel or kerosene. In this study four petroleum based products -- diesel fuel, Basal Oil, Rite Way, and Penetrator -- and a vegetable oil, Soy-Dex, were evaluated as diluents for the control of green ash (*Fraxinus pensylvanica*), and black birch (*Betula lenta*) with low volume basal bark applications of Garlon 4. Naturally growing stands of ash and birch with stem calipers ranging from 1 to 4 in were selected for treatment. A solution of 20% Garlon 4 and 80% diluent (v/v) was used for each of the five diluents. Each solution was applied at two rates; 1.0 and 2.0 ml solution per inch of stem circumference. Each solution was applied to 20 stems, arranged in a randomized complete block with four replications, five stems per replicate.. In early April 1989, the diameter of each stem was measured and recorded, circumference was determined, and the appropriate dose was calculated. The solution was applied evenly around the stem at a height of 12 to 18 in using a hypodermic needle and syringe to control accuracy. Each stem was rated for control on a scale of 0-5 with 0 being no treatment effect and 5 indicating no visible living tissue. Ash was rated in September, 1989 and August, 1990, and birch was rated in September, 1989 and 1990.

TABLE 3: Mean injury ratings to green ash and black birch treated in April 1989 with a 20% solution of Garlon 4 in five diluents, and evaluated September 1989 and August and September 1990. Injury was rated on a 0 to 5 scale, with 0 indicating no treatment effect, and 5 indicating death of the stem. Each value is the mean of 20 observations.

		Injury Ratings			
	ml solution/inch	Green Ash		Black Birch	
Diluent	stem circumference	9/89	8/90	9/89	9/90
		(-------------------- 0 - 5		------------------------)	
Diesel Fuel	1.0	5.0	5.0	3.8	4.9
Diesel Fuel	2.0	5.0	5.0	4.6	5.0
Basal Oil	1.0	5.0	5.0	2.6	4.4
Basal Oil	2.0	5.0	5.0	3.5	4.8
Rite Way	1.0	4.8	4.8	4.3	5.0
Rite Way	2.0	5.0	5.0	4.5	4.9
Soy-Dex	1.0	4.0	3.6	1.9	3.6
Soy-Dex	2.0	4.0	4.3	3.3	4.3

Penetrator	1.0	4.8	4.8	3.0	4.6
Penetrator	2.0	4.8	4.9	3.8	4.9
L.S.D. (p=0.05)	0.9	1.2			

The means for injury rating at each rating date are reported in Table 3. In 1989, ash control with Soy-Dex was significantly lower than all other treatments. Virtually complete control was achieved with diesel fuel, Basal Oil, Rite Way, and Penetrator. There was no difference in control for these products at either rate. By 1990, control ratings for the low rate of Soy-Dex had decreased and were significantlly lower than all other treatments. Injury ratings for the high rate of Soy-Dex increased slightly from 1989 and were not statistically different than the other diluents. Control provided by diesel fuel, Basal Oil, Rite Way, and Penetrator did not change from 1989 to 1990.

Control of birch was variable between treatments and rates in 1989. Control ratings for the low rate of all diluents were lower compared to the high rate, but the only significant difference was between the rates of Soy-Dex. The low rate of Rite Way was significantly better than the low rate of Basal Oil, Soy-Dex, and Penetrator, but not diesel fuel. The low rates of diesel fuel and Rite Way were not significantly different than the high rates of any diluent. The only significant difference between the high rates was between diesel fuel and Soy-Dex. By 1990 the low rate of Soy-Dex was not different than the low rate of Basal Oil or Penetrator, but was significantly lower than all other treatments. All other diluents and rates were not different from each other.

Initially, birch control levels were lower than ash in 1989, but most treatments were similar by 1990. In both species, the 1 ml solution/inch circumference rate was the most cost efficient. Soy-Dex was the only diluent that was inferior to diesel fuel. All other diluents provided the same level of control when compared to diesel fuel. None of the diluents were superior to diesel fuel.

PLANT GROWTH REGULATOR STUDIES

In 1990, four plant growth regulator (PGR) studies were conducted at the Landscape Management Research Center.

1. The Effect of Application Timing on the Activity of PGR's Applied to Tall Fescue - six PGR treatments were applied prior to seedhead emergence at five dates to determine if PGR activity was affected by application timing.
2. Pre-Mow and Post-Mow Applications of PGR's to Tall Fescue - five PGR treatments were compared when applied pre- and post-mow
3. Effects of Addition of UAN to PGR's Applied to Tall Fescue - a UAN solution of 28% nitrogen was added to four PGR treatments at rates of 0, 7, and 14 lbs N/acre to determine if the added nitrogen would affect PGR activity.
4. Comparison of CGA 163935 and Established PGR Combinations Applied Pre-Mow to Tall Fescue - CGA 163935, an experimental PGR, was applied at three rates for comparison with currently used PGR's.

All of these experiments were conducted in small plots . Large scale plots treated with commercial application equipment were established in Lancaster County, and were viewed during the 1990 Roadside Vegetation Management Conference in June. Table 1 lists the product names, active ingredients, formulation, and manufacturer of PGR's used in 1990 research.

TABLE 1: Products used in PGR studies in 1990.

Product	Active Ingedients	Formulation	Manufacturer
Embark	mefluidide	2 S	PBI/Gordon Corporation
Escort	metsulfuron methyl	60 DF	E.I. du Pont de Nemours & Co.
Event	imazethapyr + imazapyr	1.46 S	American Cyanamid Company
Telar	chlorsulfuron	75 DF	E.I. du Pont de Nemours & Co.
CGA 163935	experimental	2 EC	CIBA GEIGY Corporation

The Effect of Application Timing on the Activity of Plant Growth Regulators Applied to Tall Fescue

Previous research has suggested that different plant growth regulators (PGR's) have different periods of peak activity between the breaking of dormancy and seedhead emergence on unmown tall fescue (Festuca arundinacea). This study was initiated to determine if different plant growth regulator combinations demonstrated different activity peaks within the pre-mow application window.

The study site was seeded in the spring of 1987 to a blend of 'Cimmaron', 'Bonanza', and 'Olympic' turf type tall fescues. Prior to 1990, the area received 54 lb N/acre/year, and was maintained at a height of 3.5 in. The experimental design was randomized complete block with a split-plot treatment arrangement with three replications. Each 18 by 15 ft application timing whole plot was divided into six 3 by 15 ft PGR treatment sub-plots. The application times were April 23, April 27, May 2, May 8, and May 14, 1990. The PGR treatments were Embark, Telar, Embark plus Telar, Event, Embark plus Event, and an untreated check. The treatments were applied with a CO_2 powered hand held sprayer delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan nozzles. All PGR treatments included Banvel at 0.5 lb ae/acre and a non-ionic spray adjuvant[1/] at 0.25% (v/v). Initial visual ratings of turf color and turf quality were taken May 15 for the April 23 applications; May 29 for the April 27, May 2, and May 8 applications; and June 5 for the May 14 application. All plots were visually rated for percent seedhead suppression, turf color, and turf quality on July 2. Seedhead suppression ratings were based on the untreated check within each application time whole plot. Turf color and quality were rated on a 0 to 9 scale, with 9 being ideal, 0 dead turf, and 5 acceptable. When the data was subjected to analysis of variance, the interaction between application time and PGR treatments was highly significant for all dependent variables (Table 2).

The untreated check received the highest initial turf color ratings for each application date. The initial turf quality rating fell dramatically to unacceptable levels after the April 23 application due to the uneven appearance resulting from unchecked growth. Seedhead pressure was different between the check plots, but was always rated 0 percent suppression. July 2 ratings of turf color were barely acceptable as leaf senescence was occurring, and turf quality was unacceptable due to the presence of seedheads and uneven canopy growth.

Initial color ratings for Embark alone were acceptable and consistent for all applications. Turf quality ratings decreased for later applications as the turf grew taller with a more uneven canopy compared to other treatments. Seedhead suppression ratings taken July 2 were good to excellent for applications made April 23 and 27, then decreased significantly for turf treated May 2. Turf color and quality ratings taken July 2 followed the same trend as the seedhead suppression ratings. The color decline appeared to be due to the beginning of leaf senescence, and the quality decline was due to increasing presence of seedheads and an uneven canopy, and less favorable color ratings.

Turf treated with Telar showed an improved initial color rating between the April 23 and 27 application dates, then no change with subsequent applications. The initial quality ratings were more varied, though acceptable, and did not show any overall trend. Seedhead suppression was not acceptable for the April 23 and 27, and May 2 applications, but improved to acceptable levels for the

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[1/] CideKick II, JLB International Chemical Co., Vero Beach, FL.

May 8 and 14 applications. When rated July 2, turf color and quality were consistent and acceptable for all application dates. The combination of Embark and Telar, produced barely acceptable initial color ratings for the April 23 and 27 applications. Turf color ratings improved with the later applications, but this combination consistently received the lowest initial turf color ratings. Initial turf quality ratings for Embark plus Telar treated turf were the lowest of all treatments on the April 23 application, but by the May 14 application they were the highest, despite a change of only 6.3 to 7.0. July 2 ratings of seedhead suppression, turf color, and turf quality were good to excellent for all application dates.

TABLE 2: Visual ratings of turf color, turf quality, and percent seedhead suppression for PGR treatments applied at five different dates to tall fescue. Turf color and turf quality ratings were on a 0 to 9 scale, with '0' indicating dead turf, and '9' being ideal.Seedhead suppression was rated based on the untreated check for each application date. (n=3)

				3-4 WAT		July 2, 1990		
Date	Treatment[2/]	Application Rate (oz product/acre)	Application Rate (lb ai/acre)	Turf Color (0-9)	Turf Quality (0-9)	Sdhd. Supp. (%)	Turf Color (0-9)	Turf Quality (0-9)
4/23	Embark	24	0.375	7.0	7.3	90	7.0	7.3
4/23	Telar	0.50	0.023	5.7	6.7	67	7.0	6.7
4/23	Embark + Telar	12 + 0.25	0.188 + 0.012	5.0	6.3	93	7.0	7.7
4/23	Event	8	0.092	6.3	7.0	83	7.0	7.0
4/23	Embark + Event	8 + 4	0.125 + 0.046	5.3	6.7	93	7.0	7.0
4/23	untreated check	- - -	- - -	8.0	7.3	0	5.0	4.3
4/27	Embark	24	0.375	6.7	5.7	85	6.3	7.0
4/27	Telar	0.50	0.023	6.3	6.3	48	7.0	7.0
4/27	Embark + Telar	12 + 0.25	0.188 + 0.012	5.3	6.3	92	7.0	7.7
4/27	Event	8	0.092	6.3	6.7	92	6.7	7.3
4/27	Embark + Event	8 + 4	0.125 + 0.046	5.7	6.7	92	6.7	7.3
4/27	untreated check	- - -	- - -	8.0	4.7	0	5.0	4.0
5/2	Embark	24	0.375	7.0	5.3	8	5.0	4.0
5/2	Telar	0.50	0.023	6.3	6.7	65	7.0	6.3
5/2	Embark + Telar	12 + 0.25	0.188 + 0.012	6.0	6.7	83	7.0	7.0
5/2	Event	8	0.092	6.3	6.7	87	6.7	6.7
5/2	Embark + Event	8 + 4	0.125 + 0.046	6.0	7.0	95	7.3	7.7
5/2	untreated check	- - -	- - -	8.0	4.7	0	5.0	4.0
5/8	Embark	24	0.375	7.3	5.3	13	5.0	4.7
5/8	Telar	0.50	0.023	6.3	5.7	80	7.0	6.7
5/8	Embark + Telar	12 + 0.25	0.188 + 0.012	6.3	6.3	90	7.7	7.3
5/8	imazethapyr + Event	8	0.092	7.0	6.3	83	6.3	6.3
5/8	Embark + Event	8 + 4	0.125 + 0.046	6.7	6.7	90	7.0	7.3
5/8	untreated check	- - -	- - -	8.0	4.3	0	5.0	4.0
5/14	Embark	24	0.375	6.7	4.7	55	5.7	5.3
5/14	Telar	0.50	0.023	6.3	6.3	83	7.0	6.7
5/14	Embark + Telar	12 + 0.25	0.188 + 0.012	6.0	7.0	95	7.3	7.0
5/14	Event	8	0.092	6.3	6.7	97	7.0	7.7

5/14 Embark + Event	8 + 4	0.125 + 0.046	6.0	6.3	93	7.0	7.0
5/14 untreated check	- - -	- - -	7.7	4.0	0	5.0	4.0
Significance Level (P)			0.042	0.001	0.001	0.001	0.001
LSD (P=0.05)			0.6	1.0	14	0.6	0.8

2/ All treatments included dicamba at 0.5 lb ae/acre and non-ionic spray adjuvant at 0.25% (v/v).

Event treated plots received initial turf color and turf quality ratings between 6.3 and 7.0 for all application dates. Seedhead suppression was good to excellent for all application dates, as was turf color and turf quality when rated July 2. Adding Embark to Event produced initial turf color ratings that were consistently lower, though acceptable, than Event alone. Initial turf quality differences between the two treatments were not apparent. Embark plus Event consistently provided excellent seedhead suppression, and was among the highest rated for July 2 turf color and quality.

Under the conditions of this study, Embark showed greater activity on tall fescue in earlier applications. When combined with a reduced rate of Telar, early applications caused more discoloration, but seedhead suppression was improved. Similar results were found when Embark was combined with Event, though improvements in seedhead suppression were not as pronounced as with Telar.

Pre-Mow and Post-Mow Applications of PGR's to Tall Fescue

Embark alone, and in combination with Telar or Event , and CGA 163935 were evaluated for plant growth regulator (PGR) effects after pre-mow and post-mow application to a stand of tall fescue. The tall fescue received 54 lb N/acre/year during 1988 and 1989, and was mowed weekly with a rotary mower returning clippings at a height of 3.5 in. The treatments were applied May 14, 1990 using a CO_2 powered, hand-held boom delivering 17 GPA at 30 psi with Spraying Systems 8002 flat fan nozzles. The turf canopy height was 6 to 7 in, and some tall fescue seedheads were just emerging. The post-mow plots were mowed at 3.5 in with clippings removed just prior to treatment application. The experimental design was a randomized complete block with a split-plot treatment arrangement using three replications. The mow treatment whole plots were 15 by 15 ft, with five 3 by 15 ft PGR treatment sub-plots randomized within each whole plot. Each PGR treatment included 0.5 lb ai/acre dicamba and a non-ionic spray adjuvant at 0.25% (v/v). Visual ratings of percent seedhead suppression, turf color, and turf quality were taken July 3, 1990. Seedhead suppression was rated relative to the untreated check, and turf color and quality were rated on a 0 to 9 scale, with a rating of 0 indicating dead turf, 9 ideal turf, and 5 the lowest rating for acceptable turf. The data was subjected to analysis of variance, and the interaction between mowing and PGR treatment was significant for turf quality, and nearly significant for seedhead suppression

(P=0.07). The effect of mowing was not significant for any dependent variable, and PGR treatment effects were highly signifcant for all dependent variables. The results for the mowing by PGR interaction effects, and PGR treatment effects are reported in Tables 3 and 4, respectively.

There were fewer seedheads in the untreated check in the post-mow plots compared to the pre-mow plots due to removal during mowing, but this is not reflected in the results as the untreated checks were given a rating of 0 percent seedhead suppression. Turf color ratings were the same for each mow treatment, and were significantly lower than the best PGR treatments due to leaf senescence. Turf quality was rated as unacceptable for the untreated check, and was significantly lower than all PGR treatments due to presence of seedheads and the lower turf color ratings.

TABLE 3: Seedhead suppression, turf color, and turf quality ratings on July 3 for pre- and post-mow PGR treatments applied May 14 to tall fescue (n=3).

Mowing	PGR[3/]	Application Rate	Seedhead Suppression	Turf Color	Turf Quality
		(oz product/acre)	(%)	(0-9)	(0-9)
Post-mow	Embark	24	90	6.3	6.7
Pre-mow	Embark	24	75	6.0	5.0
Post-mow	Embark + Telar	12 + 0.25	97	7.3	7.7
Pre-mow	Embark + Telar	12 + 0.25	95	7.3	7.3
Post-mow	Embark + Event	8 + 4	97	7.0	7.3
Pre-mow	Embark + Event	8 + 4	95	6.7	6.7
Post-mow	CGA 163935	24	40	5.3	5.3
Pre-mow	CGA 163935	24	50	5.3	5.0
Post-mow	Untreated Check	- - -	0	5.7	4.3
Pre-mow	Untreated Check	- - -	0	5.7	4.0
Significance Level (P)			0.0738	0.9636	0.0431
LSD (P=0.05)			n.s.	n.s.	0.7

TABLE 4: Seedhead suppression, turf color, and turf quality of five PGR treatments averaged over pre- and post-mow applications (n=6).

PGR[3/]	Application Rate	Seedhead Suppression	Turf Color	Turf Quality
	(oz product/acre)	(%)	(0-9)	(0-9)
Embark	24	83	6.2	5.8
Embark + Telar	12 + 0.25	96	7.3	7.5
Embark + Event	8 + 4	96	6.8	7.0
CGA 163935	24	45	5.3	5.2
Untreated Check	- - -	0	5.7	4.2
Significance Level (P)		0.0001	0.0001	0.0001
LSD (P=0.05)		8	0.7	0.5

3/ All treatments included dicamba at 0.5 lb ae/acre and non-ionic spray adjuvant at 0.25% (v/v).

Embark alone did not perform as well as when combined with other PGR's. Seedhead suppression was rated at 75 percent for the pre-mow and 90 percent for the post-mow applications. It should be emphasized that the post-mow seedhead suppression represents a higher percentage of a lesser amount of seedheads, so that the difference is greater than that indicated by the 15 percent difference in ratings. This lower rating for the pre-mow treatment would be expected as the unmowed tall fescue was in the beginning phase of seedhead emergence. Previous research has shown that Embark loses effectiveness in suppressing seedheads once tall fescue reaches boot stage. There were no turf color differences between mow treatments for Embark alone, but the post-mow application was rated significantly better for turf quality, due to the greater amount of seedheads in the pre-mow plots.

Embark in combination with either Telar or Event provided excellent seedhead suppression, and received the best ratings for turf color and turf quality for both mow treatments.

CGA 163935 provided partial seedhead suppression, and the seedheads that were produced were shorter. This is not unexpected as this compound inhibits internode elongation, rather than preventing it. In the post-mow plots, a portion of the seedheads were not affected by the mowing and continued to elongate, as seedhead emergence was only beginning at the time of mowing. Turf color ratings were lower than the untreated check, and significantly lower than the other PGR's, though still acceptable. Turf quality ratings were acceptable, and significantly better than the untreated check due to presence of fewer seedheads, but were significantly lower than the other PGR treatments.

Effects of Addition of UAN to PGR's Applied to Tall Fescue

PGR treatments were applied with either 0, 2.5, or 5 gallons/acre of a UAN solution containing 28% nitrogen (0, 7.3, and 14.5 lb N/acre, respectively), to determine if the added nitrogen would have an effect on the discoloration of tall fescue often associated with PGR applications. The PGR treatments were Embark alone, and in combination with either Telar or Event , and a check which received UAN treatments only. The study was laid out as a randomized complete block with a split-plot treatment arrangement with three replications. The 3 by 15 ft PGR sub-plots were randomly assigned within each 12 by 15 ft UAN rate whole plot The treatments were applied April 25, 1990, using a CO_2 powered hand held boom delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan nozzles. The tall fescue canopy height was 3 to 5 in, with no observable signs of internode elongation. Each PGR treatment included dicamba at 0.5 lb ai/acre and a non-ionic spray adjuvant at 0.25% (v/v). Visual ratings of percent seedhead suppression compared to the check, turf color, and turf quality were taken June 5 , 41 days after treatment (DAT), and July 3 (69 DAT). Turf color and quality were rated on a 0 to 9 scale, with 0 indicating dead turf, 9 indicating an ideal turf, and 5 being the lowest acceptable rating. Ratings results for UAN rates averaged over PGR treatments, PGR treatments averaged over UAN rates, and the UAN rate*PGR treatment interactions are reported in Tables 5,6, and 7, respectively.

TABLE 5: Tall fescue seedhead suppression, turf color and turf quality ratings 41 and 69 DAT for UAN rates averaged over four PGR treatments (n=12). Treatments were applied April 25, 1990.

		------June 5 (41 DAT)------			--------July 3 (69 DAT)-------		
UAN	Actual N	Seedhead Suppression	Turf Color	Turf Quality	Seedhead Suppression	Turf Color	Turf Quality
(gal/acre)	(lb/acre)	(%)	(0-9)	(0-9)	(%)	(0-9)	(0-9)
0.0	0.0	72	7.3	6.7	72	6.5	6.0
2.5	7.3	72	7.0	6.6	67	6.6	6.1
5.0	14.5	74	6.5	6.2	70	6.3	5.9
Significance Level (P)		0.7038	0.0370	0.0968	0.2005	0.8167	0.8622
L.S.D. (P=0.05)		n.s.	0.5	n.s.	n.s.	n.s.	n.s.

After the data was subjected to analysis of variance, the only dependent variable exhibiting a significant interaction between UAN rate and PGR treatment effects was turf color rated 41 DAT. This was due to an unacceptable color rating for Embark plus Telar at the 5 gallon/acre rate of UAN on June 5, while color ratings for other treatments were not affected by UAN rate (Table 7).

TABLE 6: Tall fescue seedhead suppression, turf color and turf quality ratings 41 and 69 DAT for PGR treatments averaged over three UAN rates (n=9). Treatments were applied April 25, 1990.

		------June 5 (41 DAT)------			--------July 3 (69 DAT)-------		
PGR	Application Rate	Seedhead Supp.	Turf Color	Turf Quality	Seedhead Supp.	Turf Color	Turf Quality
	(oz product/acre)	(%)	(0-9)	(0-9)	(%)	(0-9)	(0-9)
Embark	24	96	7.0	7.7	89	6.8	6.6
Embark + Telar	12 + 0.25	97	5.9	6.7	95	6.9	6.7
Embark + Event	8 + 4	99	6.9	7.8	94	7.1	6.8
UAN-only check	- - -	0	7.9	3.8	0	5.0	4.0
Significance Level (P)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
L.S.D. (P=0.05)		3	0.5	0.9	8	0.5	0.5

TABLE 7: Tall fescue seedhead suppression, turf color, and turf quality ratings 41 and 69 DAT for PGR treatments applied with three rates of UAN (n=3). Treatments were applied April 25, 1990.

		---June 5 (41 DAT)---			------July 3 (69 DAT) ----		
UAN	PGR	Seedhead Supp.	Turf Color	Turf Quality	Seedhead Supp.	Turf Color	Turf Quality
(gal/acre)		(%)	(0-9)	(0-9)	(%)	(0-9)	(0-9)
0.0	Embark	95	7.0	8.0	93	7.0	6.7
0.0	Embark+ Telar	96	7.0	7.7	96	7.0	6.7
0.0	Embark+ Event	98	7.0	8.0	96	7.0	6.7
0.0	UAN-only check	0	8.0	3.0	0	5.0	4.0
2.5	Embark	96	7.3	7.7	80	7.0	6.7
2.5	Embark+ Telar	95	6.3	7.0	93	7.3	6.7
2.5	Embark+ Event	99	6.7	7.7	95	7.0	7.0
2.5	UAN-only check	0	7.7	4.0	0	5.0	4.0
5.0	Embark	96	6.7	7.3	93	6.3	6.3
5.0	Embark+ Telar	99	4.3	5.3	95	6.3	6.7
5.0	Embark+ Event	99	7.0	7.7	90	7.3	6.7
5.0	UAN-only check	0	8.0	4.3	0	5.0	4.0
Significance Level (P)		0.8166	0.0006	0.1012	0.6039	0.4211	0.9695
L.S.D. (P=0.05)		n.s	0.8	n.s	n.s	n.s	n.s

UAN rate effects were significant for turf color rated 41 DAT, due primarily to the unacceptable rating for Embark plus Telar at the 5 gal/acre rate. UAN rate effects were almost significant (P=0.097) for turf quality ratings 41 DAT, due to the influence of the poor color ratings for Embark plus Telar. Seedhead suppression at either rating date, and turf color and turf quality ratings for July 3 were not influenced by UAN rate (Table 5).

All three PGR combinations provided excellent seedhead control compared to the UAN-only check at both rating dates (Table 6).. All treatments were rated as acceptable for turf color 41 DAT, but there were significant differences. The UAN-only check was significantly better than all other treatments, and Embark alone or in combination with Event was rated significantly better than Embark plus Telar. For turf color ratings 69 DAT the UAN-only check was rated as barely acceptable due to leaf senescence. The three PGR treatments were rated significantly better than the check, but there was no significant difference between them. The UAN-only check was rated as unacceptable for turf quality 41 DAT, due to uneven canopy appearance and the presence of seedheads. Embark plus Telar was rated significantly lower than Embark alone and with Event due to greater discoloration. At 69 DAT, the three PGR treatments were rated very similarly, and provided significantly better turf quality than the UAN-only check, which was rated unacceptable due to a ragged appearance from unchecked growth, senescent leaves, and seedheads.

Under the conditions of this study, the addition of nitrogen in the form of UAN did not positively affect turf treated with PGR's, and at high rates actually resulted in greater discoloration to turf treated with Embark plus Telar.

Comparison of CGA 163935 and Established PGR Combinations Applied Pre-Mow to Tall Fescue

Three rates of CGA 163935, Embark, Embark plus Telar, Embark plus Escort, Embark plus Event , and an untreated check were applied to tall fescue on April 26, 1990. The tall fescue was at 100 percent greenup, with a canopy height of 3 to 5 in, and no indication of internode elongation was observed. The experimental plots were 3 by 15 ft, arranged in a randomized complete block design with three replications. The tall fescue was maintained at 3.5 in with a rotary mower returning clippings, and received 54 lb N/acre/yr in 1988 and 1989. The treatments were applied with a CO_2 powered hand held boom, delivering 17 GPA at 30 psi with Spraying Systems 8002 flat fan nozzles. All PGR combinations included dicamba at 0.5 lb ai/acre and a non-ionic spray adjuvant at 0.25% v/v. Visual ratings of percent seedhead suppression, turf color, and turf quality were taken June 5 and July 3, 39 and 67 days after treatment, respectively. Seedhead suppression was rated against the untreated check. Turf color and quality were rated on a 0 to 9 scale, with 0 being dead turf, 9 ideal turf, and 5 the lowest acceptable rating. Application rates and results are reported in Table 1.

The untreated check was rated at 0 percent seedhead suppression at both rating dates. For the June 5 rating, turf color was rated excellent, but turf quality was barely acceptable due to unchecked growth and the presence of seedheads. When rated July 3, the turf color rating had declined to 5.3 due to senescence of the older leaves, and turf quality was rated as unacceptable at 4.0.

Embark alone and in combination with Telar, Escort, and Event provided good to excellent seedhead suppression, and acceptable turf color and quality ratings. Embark plus Event plots were rated best for color and quality at the June 5 ratings, but by July 3, there were no significant differences between any of the Embark combinations.

TABLE 8: Percent seedhead suppression, turf color, and turf quality ratings taken June 5 and July 3 for PGR treatments applied April 26, 1990. Turf color and quality were rated on a 0 to 9 scale, with 0 being dead turf, 9 ideal turf, and 5 the minimum rating for acceptable turf.

		June 5			July 3		
Products	Application Rate	Seedhead Suppression	Turf Color	Turf Quality	Seedhead Suppression	Turf Color	Turf Quality
	(lb ai/acre)	(%)	(0-9)	(0-9)	(%)	(0-9)	(0-9)
1. Embark	24	93	6.7	7.0	93	7.7	6.7
2. Embark +Telar	12 + 0.25	93	6.7	7.0	93	7.7	7.0
3. Embark + Escort	8 + 0.125	77	6.3	6.3	67	7.0	6.7
4. Embark + Event	8 + 4	99	8.0	8.0	90	8.0	6.3
5. CGA 163395	24	37	7.0	6.0	37	6.7	4.3

6. CGA 163395	36	50	6.3	6.3	47	6.7	5.0
7. CGA 163395	48	55	7.0	6.3	33	7.3	5.0
8. Untreated Check	- - -	0	8.0	5.0	0	5.3	4.0
Significance Level (P)		0.001	0.023	0.015	0.001	0.013	0.001
LSD (P=0.05)		26	1.1	1.3	33	1.3	1.2

1/ All combinations included dicamba at 0.5 lb ai/acre and non-ionic spray adjuvant at 0.25% (v/v).

CGA 163935 did not provide the degree of seedhead suppression that the Embark combinations did. This result was expected, as CGA 163935 acts to reduce internode elongation rather than prevent it. Seedheads observed in CGA 163935 plots were shorter than those in the untreated check, and increasing rates of CGA 163935 were observed to decrease seedhead elongation. There were no significant differences in turf color or quality ratings between the three rates of CGA 163935. Turf color and quality ratings were acceptable at the June 5 rating, but turf quality declined and was rated unacceptable to barely acceptable at the July 3 rating, due to the presence of seedheads.

EVALUATION OF LOW MAINTENANCE GRASSES

There are currently six different studies designed to evaluate low maintenance grasses:

1. Comparison of Several Grass Species under Low Maintenance Conditions - Salunga, Lancaster County, interchange of SR 283 and SR 230. No data was collected from this study in 1990, but it was featured at the 1990 Roadside Vegetation Management Conference.
2. Comparison of Several Grass Species under Low Maintenance Conditions - Tyrone, Blair County, median of SR 220
3. Evaluation of Several Grass Species under Mowed and Unmowed Conditions - University Park, Centre County, Landscape Management Research Center.
4. Response of Hard Fescue and Tall Fescue to Different Establishment Methods - Lancaster, Lancaster County, interchange of SR 30 and SR 222.
5. Effects of Maintenance Intensity on Fine Fescue Varieties - Pennsylvania Furnace, Centre County, Penn State Horticulture Research Farm.
6. Effects of Different Mowing Frequencies on Fine Fescues and Tall Fescues - University Park, Centre County, Landscape Management Research Center.

Except for the establishment method study in Lancaster, all of these are long term studies that will be monitored for several years.

Comparison of Several Grass Species under Low Maintenance Conditions

In September, 1987, a study including seven individual species and five combinations was established on a roadside site in Tyrone, Blair County, in a median area on a closed portion of SR 220. The site was treated with 3 lb ae/acre glyphosate to kill existing vegetation, mowed, scarified with a tractor-mounted turf overseeder, and drop-seeded with 100 lb seed/acre. Individual plots were 12 by 30 ft, arranged in a randomized complete block design with three replications. No lime or fertilizer was applied to the study area. A selective broadleaf herbicide application of 2,4-D, MCPP, and dicamba at 1.22, 0.65, and 0.11 lb ae/acre respectively was applied June 17,1988. The Tyrone site was mowed the first time August 7, 1990. Visual ratings of percent turf and weed cover were taken July 3, and are reported in Table 1. The predominant weed was white sweetclover (Melilotus alba), which was 5 to 7 ft and in full bloom when rated. The sum of turf and weed coverage often exceeds 100 percent as two plant canopies were rated within each plot. The treatments and rating results are reported in Table 1.

Data for 'Tioga' deertongue grass is not reported as almost no plants were observed in the plots in 1988. In subsequent years, coverage has increased to an average of 30 percent . The six treatments including hard or creeping red fescue provided excellent cover, and were significantly better than all other treatments. When combined with either hard or creeping red fescue, tall fescue (Treatments 8,10) was present only as isolated clumps, and perennial ryegrass was not observed (Treatment 9). Turf-type and 'Kentucky 31' tall fescue provided similar, and acceptable, performance, and were virtually indistinguishable as the turf-type was as coarse as the 'Kentucky 31' under these conditions. Perennial ryegrass went through a significant decline between September, 1989, and this rating, and remains only as stunted, isolated clumps, resulting in almost no turf cover in ryegrass-only plots, and only tall fescue in the combination plots (Treatment 11). Canada bluegrass has established thin, but even stands which have low weed pressure despite the lack of turf density.

TABLE 1: Visual ratings of percent turf and weed cover taken July 3, 1990, on plots established September, 1987, on a highway median near Tyrone, PA.

Variety	Turf Cover July 3	Weed Cover July 3
	(%)	(%)
1. 'Kentucky 31' tall fescue	77	43
2. 'Transition Blend'[1/] turf type tall fescue (TTTF)	75	53
3. 'Ensylva' creeping red fescue	94	17
4. 'Aurora' hard fescue	98	19
5. 'Reubens' Canada bluegrass	53	20
6. 'Double Eagle Blend'[2/] perennial ryegrass	9	77
7. creeping red fescue/hard fescue (70/30)	93	32
8. hard fescue/TTTF (90/10)	95	14
9. hard fescue/perennial ryegrass (90/10)	94	23
10. hard fescue/creeping red fescue/TTTF (80/10/10)	97	14
11. TTTF/perennial ryegrass (70/30)	55	57
Significance Level (P)	0.0001	0.0006
LSD (P=0.05)	15	27

1/ A blend of 'Cimmaron', 'Bonanza', and 'Olympic' turf type tall fescues.

2/ A blend of 'Citation II', 'Birdie II', and 'Omega II' perennial ryegrasses.

Results from this study indicate that perennial ryegrass is unsuitable for low maintenance applications, as it has almost disappeared after three growing seasons. Under the unmowed conditions of this study, the treatments including creeping red and hard fescues flourished. It has also been demonstrated that 'no maintenance' grass is not feasible, as even treatments with excellent cover ratings still had significant amounts of white sweetclover, which when growing to heights of 7 ft is unacceptable for roadside settings.

Evaluation of Several Grass Species under Mowed and Unmowed Conditions

Eleven single species treatments, four mixtures, and an unseeded check were established September 16, 1988, in University Park, Centre County, at the Landscape Management Research Center of The Pennsylvania State University. Site preparation methods were the same as those used in the Tyrone study. The seed treatments were drop seeded on 12 by 30 ft plots, arranged in a randomized complete block design with three replications. Half of each plot was mowed for a field day in June, 1989, and the entire area was mowed with a Carter forage harvester July 6, 1989, for yield measurements. Beginning in 1990, half of each plot was mowed three times, and the other half was unmowed. Mowing dates were May 22, July 25, and October 16. Incorporation of mowing into the study changed the experimental design to a randomized complete block with a split-block treatment arrangement,. Visual ratings of percent turf and weed cover were taken May 8, July 25, and October 16, 1990. When the rating data were subjected to analysis of variance, the interaction of species and mowing was not significant for turf or weed cover on July 25 (p=0.79, 0.92, respectively), and was significant at the p=0.10 level for October 16. Results for May 8 and July 25 are reported by species in Table 2, and the results for species under each mowing treatment for October 16 are reported in Table 3. Mowing did not significantly affect turf or weed cover July 25 or October 16.

When rated May 8, the only species offering poor performance was 'Barclay' perennial ryegrass, which seemed to suffer from extensive winter-kill, and was rated at 37 percent cover (Table 2). All other species were rated at 82 percent or greater for turf cover, including the perennial ryegrass blend, which showed no signs of winter stand reduction. The 'D.O.T.' plots consisted entirely of fine fescues, with no sign of the original 'Barclay' or 'Highland' colonial bentgrass content. Plots seeded to creeping red fescue produced almost no seedheads, and hard fescue plots produced few seedheads. Tall fescue and perennial ryegrass plots produced the most seedheads. In the perennial ryegrass/tall fescue plots, (Treatments 13-15) the tall fescue component was dominant , and almost no perennial ryegrass was observed in the plots seeded to 70% tall fescue/30% perennial ryegrass. The 'Kentucky 31' and 'Transition Blend' tall fescue plots were nearly indistinguishable in appearance under these conditions. The ratings for July 25 were similar to May 8, as all treatments provided better than 90 percent cover, except 'Barclay' perennial ryegrass, which was rated at 53 percent turf cover, and 58 percent weed cover. The predominant weed in the 'Barclay' and sweet vernal grass plots was quackgrass (Agropyron repens).

There were observable differences in species behavior under different mowing treatments for the October 16 ratings. Canada bluegrass plots were rated higher for turf cover in unmowed plots, while the perennial ryegrass blend, 'Barclay' perennial ryegrass, and sweet vernal grass were rated higher in the mowed plots. All other treatments provided nearly 100 percent turf cover under both mowing conditions (Table 3).

Response of Hard Fescue and Tall Fescue to Different Establishment Methods

A study designed to evaluate the effects of site preparation and seeding method on establishment tall fescue and hard fescue was established in Lancaster, Lancaster County, at the interchange of SR 30 and SR 222. The existing vegetation was killed with glyphosate at 3 lb ae/acre September 16, and site preparation and seeding were done September 28, 1989. Site preparation treatments were mowing alone, or mowing and two passes with a disk. 'Kentucky 31' tall fescue and 'Aurora' hard fescue were seeded using a drop spreader or a cultipacker seeder. The experimental design was a randomized complete block with a 2 by 2 by 2 factorial treatment arrangement with four replications. Each plot was 6 by 30 ft. After site preparation, prior to seeding, 2 tons/acre of agricultural lime and 860 lbs/acre of 10-20-20 fertilizer were applied to the study area. A selective broadleaf weed application of 2,4-D, dicamba, and triclopyr at 0.5, 0.5, and 0.38 lb ae/acre was made May 18, 1990. The primary weeds were common chickweed (Stellaria media), shepherdspurse (Capsella bursa-pastoris), field pennycress (Thlaspi arvense), and Japanese brome (Bromus japonicus). The site was mowed July 2 and Sept 13 with a flail mower at 3 in. Visual ratings of percent turf cover and weed cover were taken May 10, August 9, and December 10, 1990. The data was subjected to analysis of variance, and means were separated using Fisher's Protected l.s.d. (P=0.05).

The effect of species, site preparation, or seeding method was not significant for the May 8 ratings of turf and weed cover (Table 5). There was a significant interaction between species and seeding method, as tall fescue turf cover was rated significantly higher when drop seeded compared to cultipacker seeding, while hard fescue turf cover was rated slightly higher for cultipacker seeding (Table 4).

When rated August 9, five weeks after mowing, all treatment combinations provided excellent turf cover. Despite a turf cover rating difference of only 3 percent, tall fescue was significantly better than hard fescue. Tall fescue also had significantly lower weed cover. The effect of site preparation was also significant for the August ratings, with disked plots rated significantly lower for weed cover than undisked plots (Table 5).

Only species contributed a significant effect for the December 10 ratings. Tall fescue provided more turf cover and less weed cover than hard fescue, though both species provided excellent cover (Table 5).These results indicate that both hard fescue and tall fescue will establish well and provided excellent ground cover with minimal site preparation under the conditions present at this site.

Effects of Maintenance Intensity on Fine Fescue Varieties

Fine fescues have performed well in low maintenance grass tests established for this project, but to date, only a handful of varieties have been evaluated. The objective of this study is to evaluate a broad spectrum of fine fescue varieties under two maintenance intensities. The lower maintenance plots will be mowed once per year and receive no supplemental fertilizer or weed control treatments, while the higher maintenance level will consist of a single mowing, plus supplemental nitrogen fertilizer and weed control as needed. This study includes 24 varieties of five, fine fescue species and two low growing perennial ryegrass varieties targeted for lower maintenance situations. This study was initially seeded with a drop spreader May 8 to a well prepared seedbed at the Penn State Horticulture Research Farm. A cultipacker was run over the plots May 9. The drop spreader had been calibrated using one variety of each fine fescue species, and it was subsequently discovered that some varieties were seeded at lower rates. After recalibrating the spreader for each variety and calculating the actual seeding rate, a supplemental seeding with a shaker jar was done May 31 so that all plots received a total of 86 lb seed/acre from the two seedings. The experimental design is a randomized complete block with a split-block treatment arrangement and three replications. Invididual plot size is 7.5 by 15 ft.

The plots were visually rated for initial turf and weed cover on June 26, using a 0 to 10, with 10 indicating 100 percent cover. The varieties seeded and rating results are reported in Table 6. An application of 0.75 lb ae/acre of 2,4-D was made July 16 using a backpack sprayer using a FloodJet tip to control common lambsquarters (Chenopodium album) and wild buckwheat (Polygonum convolvulus). The entire study was mowed the second week of August, and half of each plot was fertilized with 43 lb nitrogen/acre using urea on October 18.

Although there were great differences in turf cover, much of this had to do with plant size rather than plant numbers in a plot. Some of the hard fescues and sheep fescues received very low turf cover ratings, but these plots should be comparable to the better rated plots by the spring of 1991, as the the plants in these plots were in sufficient number, they were just very small. The low seeding rates some of these plots received on the May 8 seeding may have influenced these initial cover ratings.

Effects of Different Mowing Frequencies on Fine Fescues and Tall Fescues

The objective of this experiment is to evaluate the effects of mowing frequency under low maintenance conditions on fine fescue and tall fescue varieties. This study was established June 1, 1990, at the Landscape Management Research Center, at Penn State. Existing vegetation was killed with an application of glyphosate at 3 lb ae/acre, then mowed. The seedbed was prepared with a flail mower equipped with dethatching blades, making two passes perpendicular to each other. Seed was applied with hand held shaker jars to 5 by 30 ft plots. The study area was treated with 2,4-D at 0.5 lb ae/acre on July 16, using a backpack sprayer and a FloodJet tip to control wild buckwheat.

The entire study area was mowed July 25 and October 16, to remove weeds growing above the turf. Visual ratings of percent turf and weed cover were taken December 17, 1990, and are reported in Table 7. Sheep fescues and hard fescues received lower cover ratings than the other species, but all varieties established well. Mowing treatments will begin in 1991, with frequencies of once, twice, or three times per season.

TOTAL VEGETATION CONTROL STUDIES

Two experiments were conducted in the area of total vegetation control in 1990:

1. Giant Foxtail Control with Herbicides Applied to Soil with and without Surface Residue - 13 herbicides were evaluated under two surface residue conditions for control of giant foxtail.on an agricultural site in University Park, Centre County.
2. Total Vegetation Control under Highway Guiderails - 10 treatment were applied April 13 to a guiderail site on SR 220, near Tyrone, Blair County.

Table 1 lists the trade names, active ingredients, formulation, and manufacturer of herbicides used for total vegetation control research in 1990.

TABLE 1: Trade name, active ingredients, formulation, and manufacturer of herbicides used for total vegetation control research in 1990.

Trade Name	Active Ingredients	Formulation	Manufacturer
Arsenal	imazapyr	2 S	American Cyanamid Company
Banvel	dicamba	4 S	Sandoz Crop Protection Co.
Gallery	isoxaben	75 DF	DowElanco
Goal	oxyfluorfen	1.6 E	Rohm and Haas Company
Hyvar X	bromacil	80 DF	E.I. du Pont de Nemours & Co.
Karmex	diuron	80 DF	E.I. du Pont de Nemours & Co.
Krovar I	bromacil + diuron	80 DF	E.I. du Pont de Nemours & Co.
Oust	sulfometuron methyl	75 DF	E.I. du Pont de Nemours & Co.
Pennant	metolachlor	8 E	CIBA GEIGY Corporation
Roundup	glyphosate	4 S	Monsanto Company
Spike	tebuthiuron	80 W	DowElanco
simazine	simazine	4 L	several
Stomp	pendimethalin	60 WDG	American Cyanamid Company
Surflan	oryzalin	4 AS	DowElanco

1. Giant Foxtail Control with Herbicides Applied to Soil with and without Surface Residue

An experiment evaluating 13 herbicide combinations for giant foxtail (Setaria faberi) control was established in an area known to have high giant foxtail pressure as well as an accumulation of surface plant residue. The herbicides included broad spectrum, root absorbed herbicides, as well as low-solubility herbicides that work primarily at the soil surface on germinating seeds and seedlings. These herbicides were applied to plots with and without surface residue to determine if the residue would reduce the activity of the herbicides. Combinations of these two types of herbicides are often used under guiderails for total vegetation control with the assumption that the low-solubility materials provide longer activity near the soil surface than the more soil-mobile broad spectrum herbicides.

The herbicides applied were Arsenal, Oust, Hyvar X, Spike, two rates of Karmex, Surflan, Stomp, simazine, Gallery, Pennant, Goal, and Roundup. Roundup was added with each herbicide and applied alone to the check plots to eliminate winter annual weeds present at application. The treatments were applied April 6, 1990 to an area that had been in a no-till rotation of corn-oats-fallow for almost 20 years. The application equipment was a CO_2 powered hand-held sprayer, applying 19 GPA at 30 psi with Spraying Systems 8004 flat fan nozzles. The experimental design was a randomized complete block with a split-block treatment arrangement and three replications. Surface residue was removed from the no-residue plots with a tractor mounted York rake. Visual ratings of percent giant foxtail cover were taken June 29 and October 9, 12 and 26 weeks after treatment (WAT), respectively. An application of 0.56 kg ai/ha of 2,4-D was made July 6 to remove broadleaf weeds from the experimental area. Treatments and rating results are reported in Table 1.

When the giant foxtail cover data was subjected to analysis of variance, the effect of surface residue was found to be nonsignificant for the June 29 rating (p=0.42), and nearly significant for the October 9 rating (p=0.09). The interaction between herbicide and residue treatment effects was not significant June 29 (p=0.18), but was highly significant October 9 (p=0.0007), as the performance of some treatments was adversely affected by surface residue. Giant foxtail cover ratings were lower for all herbicides when applied to bare soil (Table 1). Arsenal, Gallery, and Goal showed the greatest difference in giant foxtail cover between the two surface conditions, with a 32, 50, and 33 percent difference, respectively, between bare soil and residue plots. Giant foxtail cover in plots treated with Oust, the high rate of Karmex, and Stomp were very similar between the two surface conditions. Herbicide treatment effects, averaged over soil residue conditions, were highly significant, and all treatments had significantly less giant foxtail cover than the Roundup-only check, which was rated at 62 and 87 percent 12 and 26 WAT, respectively. Oust, the high rate of Karmex, Stomp, Hyvar X, Spike, and Surflan provided excellent giant foxtail control. The 26 WAT cover ratings for these treatments ranged between 2 and 13 percent. The low rate of Karmex, simazine, Pennant, and Arsenal plots had less than 10 percent giant foxtail cover when rated 12 WAT, but at 26 WAT these treatments ranged between 22 and 41 percent giant foxtail cover. Gallery and Goal did not provide acceptable control of giant foxtail, as both were rated at 31 percent cover 12 WAT; and 47 and 58 percent, respectively, 26 WAT.

Under the conditions of this study, the broad spectrum herbicides Hyvar X, Karmex, Oust, and Spike provided season long control of giant foxtail and would not need to be combined with low solubility herbicides such as Surflan and Stomp. Surflan and Stomp could be combined with broad spectrum herbicides that have little or no residual activity to control existing vegetation as well as weeds such as giant foxtail, and reduce the possibility of off-site movement which can occur with the broad spectrum residual herbicides used in this study. Their use would be limited though, by their reduced spectrum of control.

2. Total Vegetation Control under Highway Guiderails

Ten treatments were applied to a guiderail site on an unused portion of SR 220 near Tyrone, Blair County, for evaluation of weed control and observations of off-site movement. Applications were made April 13, 1990, to 3 by 50 ft plots using a hand held CO_2 powered boom delivering 36 GPA at 30 psi using two Spraying Systems 8004E flat fan nozzles spraying the same swath. The nozzles were angled 45° apart, one angled forward, the other backward, to provide complete coverage around the guiderail posts. The plots were arranged in a randomized complete block design with three replications. Weed species present included spotted knapweed (Centaurea maculata), crownvetch (Coronilla varia), and white sweetclover (Melilotus alba). Visual ratings of percent weed cover were taken July 3. Treatments and rating results are reported in Table 3.

Weed pressure at this site was light, as the untreated check was rated at only 33 percent weed cover. All treatments provided excellent control, and there were signficant differences among the herbicide treatments. There was no indication of any of the herbicides moving off-site down the backslope adjacent to the guiderail.