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DEPARTMENT OF TRANSPORTATION

ROADSIDE VEGETATION MANAGEMENT RESEARCH REPORT SIXTH YEAR REPORT

THE PENNSYLVANIA STATE UNIVERSITY
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13. ABSTRACT (Maximum 200 words)

The sixth year report on a cooperative roadside vegetation management research project between The Pennsylvania Department of Transportation and The Pennsylvania State University.

Activities reported include:

1. Brush control research - including experiments evaluating fall foliar applications of herbicides, broadcast dormant stem applications, basal bark applications appied to four brush species, and low volume foliar applications of different formulations of Triclopyr.
2. Low maintenance grass research - evaluating species suitability, establishment methods, and initial investigations into the effect of maintenance practices on turf persistence.
3. Evaluation of plant growth regulators for roadside turf - Studies investigated the effects of spray adjuvants on PGR activity, PGR combinations on tall fescue, effects of liquid nitrogen solution (UAN) on the activity of PGR combinations, effects of increaing rates of UAN on the activity of Embark plus Telar, and the evaluation of experimental formulation applied to tall fescue.
4. Herbaceous weed control research - including the screening of herbicides for selective removal of Canada thistle from crownvetch, Basagran and Velpar tank mixes for Canada thistle control, and effects of application timing on the selectivity of Velpar and Transline.
4. Total vegetation control research - comparing experimental formulations for bareground weed control, evaluating herbicide combinations on an operational scale for bareground weed control, and evaluating small plot herbicide treatments for bareground weed control.

14. SUBJECT TERMS

Keywords: roadside vegetation management, brush control, low volume basal bark applications, plant growth regulator, PGR, mefluidide, low maintenance grass, tall fescue, hard fescue, creeping red fescue, hard fescue, creeping red fescue, total vegetation control, herbicides, weed control

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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

Report # PA91-4620 + 85-08 - Roadside Vegetation Management Research Report - Fifth 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, herbaceous weed control, and total vegetation control for guiderails and signposts. Project activities intended for demonstration purposes only 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

Brush control research evaluating four different herbicide application methods was conducted during 1991.

1. Evaluation of Fall Foliar Application of Herbicides for Brush Control - five Krenite S based treatments were applied to roadside brush in Centre County using equipment and personnel of a Department contractor.

2. Evaluation of Broadcast Dormant Stem Applications for Brush Control - treatments were applied at two sites evaluating different rates of Garlon 4, and different rates and types of spray adjuvants.

3. Evaluation of Basal Bark Treatments Applied to Four Brush Species - eleven herbicide combinations were applied as basal bark treatments to four tree species.

4. Low Volume Foliar Applications of Different Formulations of Triclopyr - Garlon 4, Garlon 3A, and an experimental formulation of triclopyr were applied to individual plants of striped maple, black cherry, and red maple, using a backpack sprayer delivering 15 GPA.

The herbicides and adjuvants used in 1991 research studies are listed in Table 1.

TABLE 1: Trade name, active ingredients, formulation, and manufacturer of herbicides and adjuvants used in brush control studies in 1991.

Trade Name	Active Ingredients	Formulation	Manufacturer
Access	triclopyr, picloram	3 OS	DowElanco
Arsenal	imazapyr	2S	American Cyanamid Company
Banvel 520	2,4-D, dicamba	2.9 OS	Sandoz Crop Protection Company
Clean Cut+Pine	adjuvant	- - -	Arborchem Products, Inc.
Escort	metsulfuron methyl	60 DG	E.I. DuPont de Nemours and Co.
EXP-4167	experimental	RTU	Rhone Poulenc Ag Company
Garlon 3A	triclopyr	3 S	DowElanco
Garlon 4	triclopyr	4 EC	DowElanco
Hy-Grade	adjuvant	- - -	CWC Chemical Company
Krenite S	fosamine ammonium	4 S	E.I. DuPont de Nemours and Co.
RiteWay	adjuvant	- - -	N.G. Gilbert Company
Roundup	glyphosate	4 S	Monsanto Company
Weedone 170	2,4-D, 2,4-DP	3.7 EC	Rhone Poulenc Ag Company
Weedone CB	2,4-D, 2,4-DP	RTU	Rhone Poulenc Ag Company
X-77	adjuvant	- - -	Valent Chemical Company
XRM-5234	adjuvant	- - -	DowElanco
XRM-5252	triclopyr	1 S	DowElanco

1. Evaluation of Fall Foliar Applications of Herbicides for Brush Control

MATERIALS AND METHODS

Fall foliar brush control treatments were applied to a roadside in Centre County, PA, to evaluate Krenite S alone and in combination with other herbicides for fall foliar applications. The treatments were applied using the crew and equipment of a Department contractor. Treatments were applied to a 10 ft vertical swath, from 5 to 15 ft high, on both sides of approximately 0.6 mile long plots on SR 2010 near Spring Mills on September 17, 1990, using a Cibilo Swinglok Model A sprayer applying 44 GPA at 30 psi. The treatments were Krenite S alone, and in combination with each of the following: Arsenal, Escort, Garlon 4, and Roundup. The treatment combinations and material costs are reported in Table 2. The Krenite S rates applied were 20 percent higher than intended, due to the failure of the researchers to adjust the rates entered into the injection computer to compensate for a swath width smaller than the existing settings on the computer. The Cibilo Model A computer has settings for swath widths of 6 to 9 ft per bank of nozzles on the spray head, in 1 ft increments. The pattern used for this application was 10 ft with two banks, or 5 ft per bank, while the injection computer was set for a 6 ft swath per bank.

The most prevalent brush species were green ash (*Fraxinus pennsylvanica*), staghorn sumac (*Rhus typhina*), elm (*Ulmus spp.*), hickory (*Carya spp.*), boxelder maple (*Acer negundo*), black cherry (*Prunus serotina*), black locust (*Robinia pseudo-acacia*), sugar maple (*Acer saccharum*), black walnut (*Juglans nigra*) and oak (*Quercus spp*.). Visual injury ratings were taken July 12, 1991, using a scale of 0 to 7, where '0' indicates no visible injury; '1' through '4' are increasing levels of injury up to '5', which indicates complete control of contacted branches; '6' indicates injury above the treated area; and '7' denotes complete control of the plant.

TABLE 2: Products, application rates in product and active ingredient (ai), and material costs for fall foliar applied brush control treatments.

Product	Application Rate (product/acre)	Application Rate (lb ai/acre)	Material Cost ($/acre)
Krenite S	9.6 qt	9.6	102.58
Krenite S + Arsenal	7.2 qt + 3 oz	7.2 + 0.047	80.27
Krenite S + Escort	7.2 qt + 1 oz	7.2 + 0.038	101.32
Krenite S + Garlon 4	7.2 + 1.5 qt	7.2 + 1.5	100.93
Krenite S + Roundup	7.2 + 2 qt	7.2 + 2.0	100.28

TABLE 3: Injury ratings taken July 12, 1991 for broadcast foliar treatments applied September 17, 1990. Treatments were applied with Cibilo Model A sprayer delivering approximately 44 GPA at 30 psi. Hyphenated ratings indicate a range of observed symptoms, and numbers in parentheses indicate the most common rating when a range is given.

	Krenite S	Arsenal Krenite S	Escort Krenite S	Garlon 4 Krenite S	Roundup Krenite S
	(---------- Injury (0 to 7)[1/] ----------)				
ash	3-6 (5)	5-7	5	4-7 (5)	5-6
sumac	4	5	6-7	5	5
elm	5	6	6	2	5
hickory	4-6	6	4	5	6
black locust	- -	4	6-7	5-7	5-6
boxelder	4	- -	4	5-6	3-7
cherry	5	5-6	4-7	- -	5-7
sugar maple	4-5	6-7	5	3-5	- -
walnut	4	4	5	4-5	- -
oak	5	5-6	- -	5	5
multiflora rose	- -	5	5	- -	5
hawthorn	4	4	- -	4-5	- -
red maple	- -	- -	3	- -	5
sassafras	- -	- -	4		7
linden	3-5	6-7	- -	- -	- -
apple	4-6	- -	- -	- -	5
hackberry	- -	- -	- -	5	6
mulberry	- -	- -	- -	7	5
birch	3-6	- -	- -	- -	- -
hemlock	0	- -	- -	- -	- -
honey locust	- -	- -	5-7	- -	- -

1/ Injury was rated on a 0 to 7 scale with '0' being no injury, '5' is complete control of contacted branches, '6' indicates translocation beyond the treated branches, and '7' being complete control of the plant. '- -' indicates the species was not present in the treatment area.

RESULTS

Injury ratings for all species rated are reported in Table 3. Krenite S alone provided complete control of contacted branches of elm, cherry, and oaks; and control of most contacted branches of staghorn sumac, boxelder, and black walnut. Results on sugar maple varied fromcontrol of most contacted branches to complete control, while hickory, and particularly ash showed considerable variation in response, ranging from incomplete control of contacted branches to injury above treated treated branches.

The addition of Arsenal to Krenite S increased brush injury in all species except black walnut, which along with black locust was the only species where complete control of the treated branches was not observed. Injury beyond the treated branches was seen in ash, elm, hickory, cherry, oak, and sugar maple.

Krenite S plus Escort provided consistent control above the treated branches in sumac, elm, and black locust. Cherry showed variable injury, ranging from incomplete control of treated branches to control of the entire plant. This combination provided complete control of treated branches in ash, black walnut, and sugar maple, and control of most treated branches in hickory and boxelder.

The combination of Krenite S and Garlon 4 resulted in injury beyond the treated branches in black locust and boxelder. Ash injury was extremely variable in this plot, with some stems showing incomplete control of treated branches, while some 30 to 40 ft plants were dead. It could not be determined if these trees were deas prior to treatment, but it is hard to understand how this treatment could have killed trees of this size. In the majority of ash stems, however, control of treated branches was complete without injury above the treatment zone.

Krenite S and Roundup provided complete control of treated branches in sumac, elm, and oak. Injury above the treated branches was observed in ash, cherry, and black locust. Results on boxelder were more variable, ranging from incomplete control of treated branches to control of the entire plant.

Understory injury was evident with treatments including Arsenal and Escort, but this seemed due to the topography of the right-of-way, as injured areas were often cut slopes or elevated areas that intercepted the spray pattern directly.

CONCLUSIONS

Even at the high rates of Krenite S used in this trial, the addition of other herbicides provided better control at equal or lower costs than Krenite S alone. Future research will be directed towards reducing application volumes and herbicide rates. The spray volume used for this study resulted in drip from treated foliage, with a resulting loss of herbicide from the leaf surface. Reducing spray volumes will reduce drip, and logically, should allow for reduction in herbicide rates.

2. Evaluation of Broadcast Dormant Stem Applications for Brush Control

Broadcast dormant stem applications are being evaluated for brush control because they offer the potential to increase opportunities for controlling brush, and provide this opportunity during the dormant season when vegetation management personnel are less busy, and off-site plants and crops are either dormant or not present, and are less susceptible to injury from accidental drift.

MATERIALS AND METHODS

Studies evaluating broadcast dormant stem applications were established April 8 and 19, 1991. Both studies were applied with a Cibilo Swinglok Jr. computerized injection sprayer using a Radiarc spray head. The Radiarc was configured with 10, 0.101 in nozzles delivering a total of 6.0 gal/min at 25 psi, and was oriented 28° from the spray vehicle to give a 8 ft horizontal spray swath. At the target speed of 5 mph, spray volume was 75 GPA.

The April 8 study was applied to 600 ft plots on a farm hedgerow in Benner Township, Centre County, PA. Predominant species were brambles (*Rubus spp*.), gray dogwood (*Cornus racemosa*), staghorn sumac (*Rhus typhina*), black cherry (*Prunus serotina*), tatarian honeysuckle (*Lonicera tatarica*) and autumn olive (*Eleagnus umbellata*). The four treatments and their costs are reported in Table 4.

The April 19 study was applied to roadside brush along I-80 in Union County, PA. The most common species were red maple (*Acer rubrum*), oak (*Quercus spp*.), mountain laurel (*Kalmia latifolia*), witch hazel (*Hamamelis virginiana*), and blueberry (*Vaccinium spp*). The six treatments consisted of Garlon 4 applied at three rates; 3, 4.5, and 6 qt/acre; with each of two rates of Clean Cut + Pine; 6 and 9 qt/acre; applied to 200 ft long plots. These treatment combinations and material costs are reported in Table 5.

Visual injury ratings were taken at both studies July 3, 1991, using a scale of 0 to 7, where '0' indicates no visible injury, '1' through '4' are for increasing levels of injury up to '5', which

TABLE 4: Products, application rate, and material costs for broadcast dormant stem treatments applied April 8, 1991, in Centre County.

Products	Application Rate (qts product/acre)	Material Cost ($/acre)
Garlon 4 + Clean Cut + Pine	6 + 3	103.36
Garlon 4 + Clean Cut + Pine	3 + 6	62.72
Garlon 4 + HyGrade	3 + 6	54.72
Garlon 4 + Clean Cut + Pine	3 + 9	70.07

TABLE 5: Products, application rate, and material costs for broadcast dormant stem treatments applied April 19, 1991, in Union County.

Products	Application Rate (qts product/acre)	Material Cost ($/acre)
Garlon 4 + Clean Cut + Pine	3 + 6	62.72
Garlon 4 + Clean Cut + Pine	4.5 + 6	86.72
Garlon 4 + Clean Cut + Pine	6 + 6	110.72
Garlon 4 + Clean Cut + Pine	3 + 9	70.07
Garlon 4 + Clean Cut + Pine	4.5 + 9	94.07
Garlon 4 + Clean Cut + Pine	6 + 9	118.07

indicates complete control of treated branches, '6' is given when plants show injury above the treatment zone, and '7' indicates the plant is completely killed.

RESULTS

Results for the April 8 study are reported in Table 6, and results from the April 19 study are reported in Table 7. At the site treated April 8, gray dogwood and brambles were effectively controlled by all treatments. Tatarian honeysuckle and cherry were not controlled by any treatments. Most treated branches of staghorn sumac were controlled by Garlon 4 plus Clean Cut at 3 qt plus 9 qt/acre, or 6 qt plus 3 qt/acre. Sumac showed almost no injury from Garlon 4 at 3 qt/acre plus either Clean Cut or HyGrade at 6 qt/acre.

Red maple and the oak species showed increasing injury with increasing rates of both Garlon 4 and spray oil at the site treated April 19. Good control of maple was provided by Garlon 4 at 6 qt/acre plus spray oil at 6 qt/acre, and Garlon 4 at 4.5 or 6 qt/acre with spray oil at 9 qt/acre. Oaks were effectively controlled with Garlon 4 at 6 qt/acre plus 6 qt/acre spray oil , and all rates of Garlon 4 with spray oil at 9 qt/acre. Mountain laurel showed more response to Garlon 4 rate than spray oil rate, and was effectively controlled at the high rates of Garlon 4. Blueberry also showed a response to increasing rates of Garlon 4, and was controlled at the high rate, but was present only in the plots treated with 6 qt/acre spray oil.

CONCLUSIONS

To date, broadcast dormant stem treatments have shown some promise, but do not yet offer a viable alternative to foliar and basal bark applications. The control spectrum observed has not been wide enough, and the delivery systems are not providing enough coverage for the volumes sprayed. Future research should focus on reduced spray volumes, and adding other herbicides to

TABLE 6: Injury ratings taken July 3 for broadcast dormant stem treatments applied April 8, 1991. Treatments were applied with a Cibilo Swinglok Jr. sprayer using a Radiarc spray head delivering about 75 GPA. Hyphenated ratings indicate a range of injury.

Garlon 4 (qt/acre)	6	3	3	3
spray oil (qt/acre)[1/]	3	6	6 (HyGrade)	9
	(---------- Injury (0-7)[2/] ----------)			
grey dogwood	5	4-5	5	5
autumn olive	4-5	- -	- -	4
sumac	3-5	1	1	3-5
cherry	1	- -	1	2
brambles	5	5	5	5
elm	- -	- -	1	1
multiflora rose	2-3	- -	- -	- -
apple	4-5	- -	- -	- -
wild grape	2	2-3	- -	1
honeysuckle	- -	1	1	1

1/ Unless indicated, the spray oil used was Clean Cut + Pine.
2/ Injury was rated on a 0 to 7 scale with '0' being no injury, '5' is complete control of contacted branches, '6' indicates translocation beyond the treated branches, and '7' being complete control of the plant. '- -' indicates the species was not present in the treatment area.

TABLE 7: Injury ratings taken July 3 for broadcast dormant stem treatments applied April 19, 1991. Treatments were applied with a Cibilo Swinglok Jr. sprayer using a Radiarc spray head delivering about 75 GPA. Hyphenated ratings indicate a range of injury.

Garlon 4 (qt/acre)	3	4.5	6	3	4.5	6
spray oil (qt/acre)	6	6	6	9	9	9
	(---------- Injury (0-7)[1/] ----------)					
red maple	1	1-2	3-6	2-3	4-5	4-6
oak	1-4	3-4	3-5	4-5	4-5	4-6
witch hazel	- -	- -	3-5	- -	4-5	4-5
mountain laurel	3	4-5	4-5	3-4	4	5
blueberry	3-4	4	4-5	- -	- -	- -
sassafras	- -	- -	- -	- -	4-5	5
birch	- -	1-2	- -	- -	- -	- -
striped maple	- -	6	- -	- -	- -	- -

brambles	- -	- -	- -	- -	5	- -

1/ Injury was rated on a 0 to 7 scale with '0' being no injury, '5' is complete control of contacted branches, '6' indicates translocation beyond the treated branches, and '7' being complete control of the plant. '- -' indicates the species was not present in the treatment area.

Garlon 4 to increase the control spectrum.

3. Evaluation of Basal Bark Treatments Applied to Four Brush Species

Basal bark herbicide applications offer a highly selective, low profile method to control brush. Applications can be made any time of year, but are most advantageous during the dormant season because access to the base of the plant is easier, there is no brownout with dormant applications, and Department personnel are less likely to be called away to other mainatenance tasks.

MATERIALS AND METHODS

Eleven herbicide treatments were applied on April 10-12 to Virginia pine (*Pinus virginia*), black birch (*Betula lenta*), trembling aspen (*Populus tremuloides*), and red maple (*Acer rubrum*). Stems treated ranged from 1 to 5 inches in diameter. The herbicide treatments and material costs are reported in Table 8. Each treatment was applied to eight stems of Virginia pine, and 10 stems of all other species. Prior to treatment, the diameter of each stem was measured, and a dosage determined based on applying 2 ml of herbicide solution per inch of circumference. This dosage covered approximately six inches of each pine stem, due to the rough, scaly bark; and 18 to 24 inches of the other species, which all have smooth bark. The herbicide solution was applied evenly around the circumference of each stem with a needle and syringe. Preliminary

TABLE 8: Treatment combinations and material costs for basal bark treatments.

Products	Percent of Mix	Material Cost ($/gallon)
1. Garlon 4/HyGrade	10/90	10.43
2. Access/HyGrade	6/94	11.27
3. Banvel 520/HyGrade	30/70	13.12
4. Banvel 520/HyGrade	50/50	18.86
5. Banvel 520/Garlon 4/HyGrade	30/10/60	19.07
6. Banvel 520/Access/HyGrade	30/10/60	24.43
7. Banvel 520/Arsenal/HyGrade	40/4/56	21.51
8. Weedone 170/Access/HyGrade	14/6/80	13.54
9. Weedone 170/Access/RiteWay	14/6/80	13.56
10. Weedone CB	100	23.68
11. EXP 4167	100	N/A

TABLE 9: Preliminary injury ratings for basal bark treatments applied in April 1991, and rated August 19, 1991.

Products	Injury Rating[1] 1	2	3	4	5
	(----------number of stems----------)				
					black birch
1. Garlon 4/HyGrade				1	9
2. Access/HyGrade			1	2	7
3. Banvel 520/HyGrade		1	3	4	2
4. Banvel 520/HyGrade				3	7
5. Banvel 520/Garlon 4/HyGrade				1	9
6. Banvel 520/Access/HyGrade					9
7. Banvel 520/Arsenal/HyGrade			1	3	6
8. Weedone 170/Access/HyGrade			1	1	8
9. Weedone 170/Access/RiteWay			1	1	8
10. Weedone CB			3	2	5
11. EXP 4167			6	3	1
					trembling aspen
1. Garlon 4/HyGrade					10
2. Access/HyGrade					10
3. Banvel 520/HyGrade					10
4. Banvel 520/HyGrade					10
5. Banvel 520/Garlon 4/HyGrade					10
6. Banvel 520/Access/HyGrade					10
7. Banvel 520/Arsenal/HyGrade					10
8. Weedone 170/Access/HyGrade					10
9. Weedone 170/Access/RiteWay					10
10. Weedone CB					10
11. EXP 4167					10

1/ Rating system: 1=no observed injury, 2=slight injury, 3=moderate injury, 4=severe injury, 5= dead.

TABLE 10: Preliminary injury ratings for basal bark treatments applied in April 1991, and rated September 9, 1991.

Products	Injury Rating[1] 1	2	3	4	5
	(----------number of stems----------)				
					Virginia pine
1. Garlon 4/HyGrade		1	1	1	5
2. Access/HyGrade			1	1	6
3. Banvel 520/HyGrade			1	1	6
4. Banvel 520/HyGrade			1	1	6
5. Banvel 520/Garlon 4/HyGrade					9
6. Banvel 520/Access/HyGrade					8
7. Banvel 520/Arsenal/HyGrade				1	7
8. Weedone 170/Access/HyGrade			3	1	4
9. Weedone 170/Access/RiteWay				1	7
10. Weedone CB			3	1	4
11. EXP 4167			2		6
					red maple
1. Garlon 4/HyGrade					10
2. Access/HyGrade					10
3. Banvel 520/HyGrade		6	1	1	2
4. Banvel 520/HyGrade		3	4	3	
5. Banvel 520/Garlon 4/HyGrade				1	9
6. Banvel 520/Access/HyGrade					10
7. Banvel 520/Arsenal/HyGrade			2	2	6
8. Weedone 170/Access/HyGrade					9
9. Weedone 170/Access/RiteWay					10
10. Weedone CB	4	2	2		2
11. EXP 4167	1	1	1		7

1/ Rating system: 1=no observed injury, 2=slight injury, 3=moderate injury, 4=severe injury, 5= dead.

ratings were taken on birch and aspen on August 19, and pine and maple were rated September 9. Each stem was rated on a scale of 1 to 5, with '1' being no treatment effect, '2' to '4' indicating increasing injury, and '5' indicating death of the stem.

RESULTS

Preliminary results for black birch and trembling aspen are reported in Table 9, and results for Virginia pine and red maple in Table 10. All stems of aspen were killed by all treatments, and no root suckers were observed around treated plants.

Control of black birch was poor with Banvel 520 at 30 percent, and EXP 4167. All other treatments killed at least half the stems treated and caused moderate to severe injury to the remaining stems.

Excellent control of red maple was provided by all treatments containing either Garlon 4 and Access. Both treatments of Banvel 520 alone, and Weedone CB provided poor control.

All treatments killed at least half of the treated stems of Virginia pine. The combinations of Banvel 520 and either Garlon 4 or Access killed all stems.

Final ratings will be taken during the summer of 1992. Conclusions about the effectiveness of the treatments should not be made until that time.

4. Low Volume Foliar Applications of Different Formulations of Triclopyr

The use of low-volume foliar applications is becoming more common on utility right-of-ways. These applications are made with backpack sprayers, and provide an effective method to selectively control small brush. Foliar applications provide the best entry of pesticide into the plant, and the use of low-volume equipment allows for precise placement of small amounts of solution on target plants.

MATERIALS AND METHODS

Garlon 3A, Garlon 4, and an experimental amine formulation of triclopyr, XRM-5252, were applied at 2.0 and 4.0 lb ai/acre with the non-ionic surfactant X-77, and Garlon 3A and XRM-5252 were also applied at the same rates with a silicone-based surfactant, XRM-5234. Treatment combinations, and material costs are reported in Table 11. The treatments were applied using a CO_2-powered backpack sprayer delivering 15 GPA at 15 psi, using a Spraying Systems #5500 adjustable ConeJet nozzle with an X-2 spray tip. Each treatment was applied to 10 stems of striped maple (*Acer pensylvanicum*) on June 18, 1991, at the Stone Valley Experimental Forest; and black cherry (*Prunus serotina*) and red maple (*Acer rubrum*) near the University Park Air

TABLE 11: Products, application rates, and material costs for low-volume foliar applications.

Products	Application Rate (product/acre)	Application Rate (lb ai/acre)	Material Cost ($/acre)
1. Garlon 3A + X-77[1/]	2.7 qt	2	33.01
2. Garlon 3A + X-77	5.3 qt	4	66.02
3. Garlon 4 + X-77	2 qt	2	32.00
4. Garlon 4 + X-77	4 qt	4	64.00
5. XRM-5252 + X-77	8 qt	2	n/a
6. XRM-5252 + X-77	16 qt	4	n/a
7. Garlon 3A + XRM-5234	2.7 qt	2	33.01
8. Garlon 3A + XRM-5234	5.3 qt	4	66.02
9. XRM-5252 + XRM-5234	8 qt	2	n/a
10. XRM-5252 + XRM-5234	16 qt	4	n/a

1/ X-77 and XRM-5234 were added at 0.25% v/v.

TABLE 12: Visual ratings of percent injury of black cherry, striped maple, and red maple, taken August 8, 1991, for low volume foliar treatments applied June, 1991.

	Percent Injury

Products	Application Rate (lb ai/acre)	Black Cherry (%)	Striped Maple (%)	Red Maple (%)
1. Garlon 3A + X-77[1/]	2	35	98	72
2. Garlon 3A + X-77	4	61	100	97
3. Garlon 4 + X-77	2	75	100	79
4. Garlon 4 + X-77	4	42	97	80
5. XRM-5252 + X-77	2	41	89	53
6. XRM-5252 + X-77	4	53	94	71
7. Garlon 3A + XRM-5234	2	55	99	- - -
8. Garlon 3A + XRM-5234	4	67	99	- - -
9. XRM-5252 + XRM-5234	2	72	99	- - -
10. XRM-5252 + XRM-5234	4	77	99	- - -

1/ All adjuvants were added at 0.25% v/v.

port on June 20, 1991. Striped maple and black cherry were treated with all treatment combinations, and red maple received treatments 1-6. Preliminary ratings of percent injury were taken at all sites on August 8, 1991, and are reported in Table 12. Final ratings of percent control will be taken in June of 1992.

RESULTS

All treatments were extremely effective on striped maple, and considerable stem death could be observed due to discoloration of the green bark. Red maple seemed to show a response to increasing rates of Garlon 3A and XRM-5252, but not to Garlon 4.

Black cherry showed less injury than the maples, and exhibited varying discoloration and wilting of the leaves, rather than the necrosis shown by the maples. When applied at the low rate, the control provided by Garlon 3A and XRM-5252 was enhanced more by the XRM-5234 than the X-77. When applied at the high rate there was little difference due to surfactant. The higher rate of chemical apparently masked any surfactant effect. An increase in injury with increase in herbicide rate was most apparent with Garlon 3A plus X-77, while XRM-5252 combined with the silicone based surfactant did not show a response to rate. Garlon 4 was actually rated with less injury at the higher rate application rate. At this point, there is no logical explanation for this.

CONCLUSIONS

Due to the preliminary nature of these results, conclusions about the performance of these different formulations will be reserved until data on percent kill is taken in 1992.

EVALUATION OF LOW MAINTENANCE GRASSES

Turf maintenance along Pennsylvania's roadsides consists primarily of mowing. The predominant species is 'Kentucky 31' tall fescue, which has a rapid growth rate and produces an abundance of tall, coarse seedheads. This grass is mowed two to six times per year, depending on the visibility of the area and the weather during the growing season.

Research at Penn State and at other sites around the country on low maintenance grasses for use in horticultural crops showed that there are currently grasses with much lower mowing requirements currently available that should be adaptable to roadside use. The following studies were initiated to determine how a variety of newer grasses would perform under roadside site and maintenance conditions; and how much site preparation would be required to establish the grasses along roadsides.

Data was collected from seven trials evaluating grasses under low maintenance conditions.

1. Evaluation of Turf Species and Mixtures for Roadside Conditions, Salunga.
2. Evaluation of Turf Species and Mixtures for Roadside Conditions, Tyrone.
3. Evaluation of Turf Species and Mixtures under Mowed and Unmowed Conditions, PSU Landscape Management Research Center (LMRC).
4. Response of Hard Fescue and Tall Fescue to Different Establishment Methods, Lancaster.
5. Evaluation of Fine Fescues and Perennial Ryegrasses under Different Maintenance Levels, PSU Horticulture Research Farm.
6. Effects of Mowing Frequency on Varieties of Fine Fescue and Tall Fescue Maintained under Roadside Conditions, PSU LMRC.
7. Performance of Fine Fescue Varieties under Low Maintenance Conditions, PSU LMRC.
8. Performance of Kentucky Bluegrass Varieties under Low Maintenance Conditions, PSU LMRC.

The common and scientific names of the species used in the various trials are listed in Table 1.

1. Evaluation of Turf Species and Mixtures for Roadside Conditions, Salunga

MATERIALS AND METHODS

Seven single species treatments and five turf mixtures (Table 2) were established in September 1987, in the interchange of SR 283 and SR 230, near Salunga, Lancaster County, PA. Prior to seeding, the site was treated with 3 lb ae/acre of glyphosate, mowed, and prepared with an Olathe model 83 turf overseeder. The treatments were drop seeded at 100 lb seed/acre onto 12 by 30 ft plots arranged in a randomized complete block design, with three replications. The area

TABLE 1: Common and scientific names of grass species used in low maintenance trials.

Common Name	Scientific Name	Experiments
colonial bentgrass	*Agrostis tenuis*	3
sweet vernal grass	*Anthoxanthum odoratus*	3
tall fescue	*Festuca arundinacea*	1,2,3,4,6
hard fescue	*Festuca longifolia*	1-7
sheep fescue	*Festuca ovina*	6,7
chewings fescue	*Festuca rubra* ssp. *commutata*	3,6,7
creeping red fescue	*Festuca rubra* ssp. *rubra*	1,2,3,4,5
slender creeping fescue	*Festuca tricophylla*	6,7
perennial ryegrass	*Lolium perenne*	1,2,3,5
deertongue grass	*Panicum clandestinum*	1,2
Canada bluegrass	*Poa compressa*	1,2,3
Kentucky bluegrass	*Poa pratensis*	3,8

TABLE 2: Visual ratings of percent turf cover and weed cover taken May 10, July 22, and October 29, 1991, for plots established September, 1987, near Salunga, PA. Each value is the mean of three replications.

	May 10		July 22		October 29	
Varieties	Turf	Weed	Turf	Weed	Turf	Weed
	(----------percent cover----------)					
1. 'Kentucky 31' tall fescue	37	58	21	24	27	55
2. turf type tall fescue blend (TTTF)[1/]	8	88	20	27	7	80
3. 'Ensylva' creeping red fescue (CRF)	75	35	7	30	17	65
4. 'Aurora' hard fescue (HF)	28	80	8	28	5	88
5. 'Reubens' Canada bluegrass	35	68	33	37	25	62
6. 'Tioga' deertongue grass	0	95	2	55	0	87
7. perennial ryegrass blend (PRG)[2/]	0	95	0	60	0	88
8. CRF/HF (70/30)	73	23	55	12	50	27
9. HF/TTTF (90/10)	35	72	24	25	20	70

10. HF/PRG (90/10)	55	47	20	40	37	47
11. HF/CRF/TTTF (80/10/10)	43	57	32	22	28	55
12. TTTF/PRG (90/10)	23	70	25	19	32	50
Probability Level (P)	0.0034	0.0683	0.0191	0.1386	0.0674	0.1017
LSD (P=0.05)	37	n.s.	27	n.s.	n.s.	n.s.

[1/] 'Transition Blend', a blend of 'Cimmaron', 'Bonanza', and 'Olympic' tall fescues.
[2/] 'Double Eagle Blend', a blend of 'Birdie II', 'Citation II', and 'Omega II' perennial ryegrasses.

has not been fertilized. Herbicide treatments to control broadleaf weeds were applied July 5, 1988 (1.22 lb ae/acre 2,4-D, 0.65 lb ae/acre MCPP, and 0.11 lb ae/acre dicamba) and October 29, 1991 (0.38 lb ae/acre triclopyr, 0.09 lb ae/acre clopyralid, and 0.012 lb ai/acre chlorsulfuron). The site was mowed once in 1989, and once in 1990. Beginning in 1991, the area was included in normal PennDOT maintenance activities, and was mowed four times at a height of approximately 2.5 in. Visual ratings of percent turf and weed cover were taken May 10, July 22, and October 29, 1991.

RESULTS

A grid sampling revealed an average soil depth of 20 in., and the overall soil quality of the site is poor and appears to be fill material. The Fall, 1987 seedings were followed by an extremely hot and dry growing season in 1988, and 1991 was also extremely hot and dry in the test area, with below average rainfall every month from April through October. All treatment combinations declined in quality compared to previous years, and all combinations seemed to be suffering from the drought, particularly on July 22. The predominant weeds were crownvetch (*Coronilla varia*) and Canada thistle (*Cirsium arvense*). Tall fescue, Kentucky bluegrass, and creeping red fescue were rated as weeds in plots where they were not seeded. Under the severe conditions imposed this year, none of the treatments provided outstanding performance. Individual plants tended to be stunted. The best performance was provided by a combination of 'Ensylva' creeping red fescue and 'Aurora' hard fescue, which was the only treatment rated higher for turf cover than weed cover by October 29. Other treatments were notable only for their lack of performance. There was almost no sign of 'Tioga' deertongue grass or perennial ryegrass in the plots where they were seeded.

CONCLUSIONS

Tioga deertongue grass and perennial ryegrass did not become successfully established in this study area. All other grasses; including the turf type tall fescues, Canada bluegrass, and the fine fescues established at least as well as the roadside standard, 'Kentucky 31' tall fescue.

2. Evaluation of Turf Species and Mixtures for Roadside Conditions, Tyrone

MATERIALS AND METHODS

Seven single species treatments and five turf mixtures (Table 3) were established September, 1987, in the median of SR 220 near Tyrone, Blair County, PA. Prior to seeding the site was treated with 3 lb ae glyphosate/acre, mowed, and prepared with an Olathe model 83 turf overseeder. The treatments were drop seeded onto 12 by 30 ft plots arranged in a randomized complete block design with three replications. The site has not been fertilized. A selective broadleaf weed treatment of 2,4-D; MCPP; and dicamba at 1.22, 0.65, and 0.11 lb ae/acre, respectively, was applied July 17,1988. The site was mowed at a height of 3.5 in on August 7, 1990. The Fall, 1987 seedings were followed by an extremely hot and dry growing season in 1988. The year the plots were rated, 1991, was also extremely hot and dry in the test area, with below average rainfall every month from April through October. Visual ratings of percent green turf and weed cover were taken May 22, August 6, and October 7, 1991.

RESULTS

Green turf cover tended to be low for the May 22 and August 6 ratings, but this was a result of dormancy and not death of the stand. Brown turf could be caused by delayed spring green-up or extended summer dormancy due to the draught the year the plots were rated. There was generally less than 5 percent bare soil in the plots. The only species that were truly poor were

TABLE 3: Visual ratings of percent green turf cover and weed cover taken May 22, August 6, and October 7, 1991, for plots established September, 1987, near Tyrone, PA. These values do not reflect total ground cover, as there was considerable dead or dormant vegetation, particularly in the fine fescue plots. Each value is the mean of three replications.

	May 22		August 6		October 7	
Varieties	Turf	Weed	Turf	Weed	Turf	Weed
	(----------percent cover----------)					
1. 'Kentucky 31' tall fescue	30	13	33	6	85	3
2. turf type tall fescue (TTTF) [1/]	27	33	32	22	77	23
3. 'Ensylva' creeping red fescue (CRF)	23	14	25	17	60	27
4. 'Aurora' hard fescue (HF)	27	6	37	15	65	18
5. 'Reubens' Canada bluegrass	23	23	1	27	47	38
6. 'Tioga' deertongue grass	8	57	8	55	4	83
7. perennial ryegrass (PRG) [2/]	5	63	1	65	12	78
8. CRF/HF (70/30)	22	11	33	19	60	23

9. HF/TTTF (90/10)	23	7	38	5	68	9
10. HF/PRG (90/10)	27	13	38	18	60	23
11. HF/CRF/TTTF (80/10/10)	37	3	35	6	77	8
12. TTTF/PRG (90/10)	20	30	35	17	73	17
Probability Level (P)	0.0117	0.0001	0.0001	0.0001	0.0001	0.0001
LSD (P=0.05)	15	21	17	21	19	18

[1/] 'Transition Blend', a blend of 'Cimmaron', 'Bonanza', and 'Olympic' tall fescues.
[2/] 'Double Eagle Blend', a blend of 'Birdie II', 'Citation II', and 'Omega II' perennial ryegrasses.

the 'Tioga' deertongue grass and the perennial ryegrass, which was very thin in ryegrass alone plots, and nearly non-existent in combination plots. Canada bluegrass was rated poorly on August 6, but this type of summer dormancy has been consistently observed with this species. 'Kentucky 31' tall fescue was rated best for turf cover October 7, and had few weeds. The turf type tall fescue also provided good turf cover, but had significantly more weeds than 'Kentucky 31'. The different fine fescue treatments performed similarly, provided excellent ground cover, but were rated lower for green turf cover than 'Kentucky 31' tall fescue. Fine fescues form a denser thatch and leaf cover layer than tall fescues, but much of the layer was brown in 1991 due to the draught.

CONCLUSIONS

Tioga deertongue grass did not become successfully established at this site, and perennial ryegrass did not persist. Reubens Canada bluegrass was established, but was not performing well under the drought conditions. The was no difference in turf or weed cover between the other species on May 22 or August 6. The Kentucky 31 and turf type tall fescues provided the highest green turf cover in October, but the cover provided by the fine fescues was acceptable.

3. Evaluation of Turf Species and Mixtures under Mowed and Unmowed Conditions, PSU LMRC

MATERIALS AND METHODS

Eleven single species treatments, four mixtures, and an unseeded check were established in September, 1988, at the Landscape Management Research Center of the Pennsylvania State University (Table 4). Prior to seeding, the site was treated with 3 lb ae/acre glyphosate, mowed, and prepared with an Olathe model 83 turf overseeder. The treatments were drop seeded onto 12 by 30 ft plots arranged in a randomized complete block design with three replications. The site was mowed once in 1989. In 1990, mowing was added as a treatment effect, and half of each plot was mowed three times with a flail mower set at 3.5 in. Due to abnormally hot and dry conditions during 1991, the plots were only mowed twice, on May 31 and November 8. A selective broadleaf weed treatment of 1 lb ae/acre 2,4-D plus 0.19 lb ae/acre clopyralid was applied September 24, 1991. Visual ratings of total ground cover, green turf cover, and weed cover were taken May 6 and June 30 (Tables 5 and 6), and turf cover and weed cover on November 7 (Table 7), 1991. Green turf cover was not always a true indication of total stand density. Brown turf could be caused by delayed spring green-up or extended summer dormancy due to the drought the year the plots were rated.

TABLE 4: Varieties seeded to low maintenance turf plots in September, 1988.

Treatment	Seeding Rate (lbs/acre)
1. 'Kentucky 31' tall fescue	100
2. 'Transition Blend' turf-type tall fescue[1/]	100
3. 'Ensylva' creeping red fescue	100
4. 'Pennlawn' creeping red fescue	100
5. 'Aurora' hard fescue (HF)	100
6. 'SR 3000' hard fescue	100
7. Kentucky bluegrass blend	75
8. 'Reubens' Canada bluegrass	75
9. 'Double Eagle Blend' perennial ryegrass[2/]	100
10. sweet vernal grass	80
11. 'Barclay' perennial ryegrass	40
12. 'D.O.T.' mixture[3/]	100
13. perennial ryegrass/turf-type tall fescue (70/30)	100
14. perennial ryegrass/turf-type tall fescue (50/50)	100
15. perennial ryegrass/turf-type tall fescue (30/70)	100
16. unseeded check	- - -

[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.

[3/] A mixture of 30% 'Barclay' perennial ryegrass, 25% creeping red fescue, 25% chewings fescue, and 20% 'Highland' colonial bentgrass.

RESULTS

The total vegetative ground cover ratings demonstrate that well established turf provides excellent ground cover even under condition of extreme draught stress. In 1991, every month from April through October experienced below average rainfall. There was a significant interaction between treatment and mowing effects for turf cover and weed cover for all three rating dates, therefore results are reported for mowed and unmowed conditions. Plots seeded to tall fescue alone and in combination with perennial ryegrass performed well at all dates, except for June 30, when turf type tall fescue seeded alone provided significantly less cover than 'Kentucky 31' and turf type tall fescue mixed with perennial ryegrass. This seems unusual, as the tall fescue/perennial ryegrass plots were seeded with turf type tall fescue, and consisted almost entirely of tall fescue. The fine fescues provided a thick low growing ground cover, and the creeping red fescues and the 'D.O.T. Mix' showed little difference in appearance between mowed and unmowed plots. The hard fescues provided better green turf cover May 6 than the creeping red fescues and the 'D.O.T. Mix', but by November 7 all fine fescue plots were providing excellent cover. The Kentucky bluegrass blend provided excellent turf cover under mowed and unmowed conditions for all three rating dates. The perennial ryegrass blend is persisting

TABLE 5: Visual ratings of total ground cover (alive and dead vegetation), green turf cover, and weed cover, taken May 6, 1991, on mowed and unmowed plots established September, 1988. Probability levels and LSD values are for the interaction of turf species and mowing effects, and apply to both columns within a cover category (n=3).

	May 6, 1991					
	total ground cover		green turf cover		weed cover	
Varieties	unmowed	mowed	unmowed	mowed	unmowed	mowed
	(---------- percent cover ----------)					
1. 'Kentucky 31' TF	100	100	73	68	3	1
2. TTTF blend	100	100	77	68	4	4
3. 'Ensylva' CRF	100	100	52	45	7	6
4. 'Pennlawn' CRF	100	100	37	43	12	13
5. 'Aurora' HF	98	100	72	62	6	11
6. 'SR 3000' HF	100	100	70	53	10	12
7. KBG blend	100	100	88	78	4	9
8. 'Reubens' CBG	100	100	32	68	13	20
9. PRG blend	100	99	67	70	23	20
10. sweet vernal grass	100	100	55	68	25	23
11. 'Barclay' PRG	92	99	9	5	73	78
12. 'D.O.T.' mixture	100	100	40	40	7	5
13. PRG /TTTF (70/30)	100	100	72	75	2	3
14. PRG/TTTF (50/50)	100	100	77	70	2	2
15. PRG/TTTF (30/70)	98	100	75	73	4	4
16. unseeded check	88	98	0	0	85	97
Probability level (P)	0.6784		0.0239		0.0546	
LSD (P=0.05)	n.s.		16		6	

better at this site than it has at similar studies in Salunga and Tyrone, PA, but when rated November 7, perennial ryegrass provided significantly less turf cover than the tall fescues, fine fescues, and Kentucky bluegrass. The mowed perennial ryegrass plots provided significantly better cover than the unmowed plots on November 7, but the ratings on May 6 and June 30 for mowed and unmowed plots were very similar. Unmowed sweet vernal grass provided poor cover on November 7, and was rated significantly lower than mowed plots, while earlier ratings were similar for mowed and unmowed plots.. 'Barclay' perennial ryegrass seemed to suffer severe winter-kill during 1989, and was rated less than 10 percent cover at all ratings. Mowing had little effect on the turf or weed cover in the tall fescue or bluegrass plots at any time of year. There was no effect on the fine fescue plots in May or November, but on June 30 there were more weeds in the unmowed than the mowed plots.

TABLE 6: Visual ratings of total ground cover (alive and dead vegetation), green turf cover, and weed cover, taken June 30, 1991, on mowed and unmowed plots established September, 1988. Probability levels and LSD values are for the interaction of turf species and mowing effects, and apply to both columns within a cover category (n=3).

	June 30, 1991					
	total ground cover		green turf cover		weed cover	
Varieties	unmowed	mowed	unmowed	mowed	unmowed	mowed
	(---------- percent cover ----------)					
1. 'Kentucky 31' TF	100	100	65	43	6	3
2. TTTF blend	100	100	43	33	16	11
3. 'Ensylva' CRF	100	100	57	37	7	3
4. 'Pennlawn' CRF	100	100	38	33	20	6
5. 'Aurora' HF	100	100	50	33	20	6
6. 'SR 3000' HF	100	100	47	25	23	6
7. KBG blend	98	100	67	68	28	13
8. 'Reubens' CBG	100	100	23	55	25	18
9. PRG blend	97	99	42	43	53	42
10. sweet vernal grass	100	100	25	23	67	57
11. 'Barclay' PRG	98	100	6	2	87	93
12. 'D.O.T.' mixture	100	100	25	25	15	5
13. PRG/TTTF (70/30)	100	100	63	55	6	3
14. PRG/TTTF (50/50)	100	100	65	52	7	1
15. PRG/TTTF (30/70)	100	100	73	53	8	2
16. unseeded check	90	98	0	0	88	97
Probability level (P)	0.0266		0.0006		0.0003	
LSD (P=0.05)	3		14		7	

CONCLUSIONS

The soil at this site was higher quality than the disturbed roadside soils at the Salunga and Tyrone sites, and overall, the grasses performed better. With the exception of the perennial

ryegrasses and the sweet vernal grass, all other species and mixes provided almost total cover throughout the year. Mowing had little or no effect on stand density of the fescues and bluegrasses, and only affected weed cover in the fine fescue plots in June.

4. Response of Hard Fescue and Tall Fescue to Different Establishment Methods, Lancaster

MATERIALS AND METHODS

This study, designed to evaluate the effects of site preparation and seeding method on the

TABLE 7: Visual ratings of turf cover, and weed cover, taken November 7, 1991, on mowed and unmowed plots established September, 1988. Probability levels and LSD values are for the interaction of turf species and mowing effects, and apply to both columns within a cover category (n=3).

	November 7, 1991			
	green turf cover		weed cover	
Varieties	unmowed	mowed	unmowed	mowed
	(percent cover)			
1. 'Kentucky 31' TF	94	95	0	0
2. TTTF blend	95	95	1	0
3. 'Ensylva' CRF	96	92	2	4
4. 'Pennlawn' CRF	91	88	5	7
5. 'Aurora' HF	88	92	3	3
6. 'SR 3000' HF	88	87	4	6
7. KBG blend	89	93	9	4
8. 'Reubens' CBG	57	65	32	27
9. PRG blend	23	55	72	40
10. sweet vernal grass	7	50	90	44
11. 'Barclay' PRG	2	0	92	88
12. 'D.O.T.' mixture	92	91	3	4
13. PRG /TTTF (70/30)	95	93	0	2
14. PRG/TTTF (50/50)	93	95	0	0
15. PRG/TTTF (30/70)	93	95	0	0
16. unseeded check	0	0	92	92
Probability Level (P)	0.0145		0.0138	
LSD (P=0.05)	17		17	

establishment of hard fescue and tall fescue for roadside conditions, was established near Lancaster, PA, at the interchange of SR 222 and SR 30. The existing vegetation was killed three weeks prior to seeding with 3 lb ae/acre glyphosate, and the killed vegetation was mowed. Seedbed preparation and seeding were done September 28, 1989. 'Aurora' hard fescue and 'Kentucky 31' tall fescue were either dropped or sown with a cultipacker seeder onto 6 by 30 ft plots that were either mowed only, or mowed and disked. The experimental design was a randomized complete block design with a 2 by 2 by 2 factorial treatment arrangement with four replications; with species, seedbed preparation, and seeding method as main effects. After seedbed preparation, but prior to seeding, all plots received 860 lbs/acre of 10-20-20 fertilizer and 2 tons/acre of agricultural lime. An application of 2,4-D; dicamba; and triclopyr; at 0.5, 0.5, and 0.38 lb ae/acre, respectively, was made May 18, 1990, to control broadleaf weeds. The area, included in normal PennDOT

maintenance practices for the area, was mowed twice in 1990 and three times in 1991, at a height of 2.5 in. In 1991, visual ratings for percent turf cover and weed

cover were taken May 10, July 22, and October 29. This year was extremely hot and dry in the test area, with below average rainfall every month from April through October.

RESULTS

The results for species, seeding method, and seedbed preparation are reported in Table 8. The effect of species was significant for turf cover on May 10 and July 22. On May 10, prior to mowing, tall fescue provided better cover than hard fescue and had fewer weeds. July 22 ratings were taken after mowing, and hard fescue provided significantly more turf cover, due to a higher turf stand density. The tall fescue plots have a much thinner stand than the hard fescue plots, so removal of the foliage has more of an effect on cover. Except for a slight difference on July 22, there was no difference in cover caused by seeding method. The effects of seedbed preparation were not significant at any rating date. A summary of the results for the interaction of species, seeding method, and seedbed preparation is presented in Table 9.

CONCLUSIONS

Hard fescue and tall fescue were successfully established at this site by simply dropping their seed on areas that had been killed, and then mowed.

5. Evaluation of Fine Fescues and Perennial Ryegrasses under Different Maintenance Levels, PSU Horticulture Research Farm

MATERIALS AND METHODS

A study evaluating 24 fine fescue varieties and two varieties of perennial ryegrass (Table 10) under two maintenance levels was established May 8, 1990, at the Penn State Horticulture Research Farm, Rock Springs, PA. Prior to seeding, the site had been plowed, disked, and harrowed. The seed was dropped onto 7.5 by 30 ft plots arranged in a randomized complete block design with three replications. After seeding, the area was cultipacked. A treatment of 0.75 lb ae/acre 2,4-D was applied July 16, 1990, to control common lambsquarters (*Chenopodium album*) and wild buckwheat (*Polygonum convolvulus*). The entire study was mowed in August, 1990, and September, 1991. Half of each plot received 43 lb/acre of nitrogen from urea on October 18, 1990, and October 8, 1991. To date, the fertilization of half of each plot is the only difference in the maintenance of the plots. Visual ratings of turf and weed cover were taken June 26, 1990, on a scale of 0 to 10, with 0=0 percent cover and 10=100 percent cover, and are reported as percent cover in Table 11. Visual ratings of percent total ground cover (alive or dead vegetation), green turf cover, and weed cover were taken May 13, August 4, and October 9, 1991. This year was extremely hot and dry in the test area, with below average rainfall every

TABLE 8: Effects of species, seeding method, and tillage on visual ratings of turf and weed cover taken May 10, July 22, and October 29, 1991, for plots established September, 1989. Each value is the mean of 16 observations.

	May 10		July 22		October 29		
Treatment	Turf	Weed	Turf	Weed	Turf	Weed	
	(---------- percent cover ----------)						
SPECIES							
hard fescue	82		20		81		7
tall fescue	95		2		53		1
Probability Level (P)	0.0079	0.0009	0.0001	0.0019	0.0713	0.0029	
LSD (P=0.05)	10	10	3	4	n.s.	6	
SEEDING METHOD							
cultipacker	87		13		65		4
drop	90		10		70		4
Probability Level (P)	0.5699	0.4880	0.0027	0.7359	0.6383	0.8136	
LSD (P=0.05)	n.s.	n.s.	3	n.s.	n.s.	n.s.	

SEEDBED PREPARATION

disk	93		8		67	4
none	84		15		68	5
Probability Level (P)	0.0601	0.1947	0.2278	0.6707	0.5937	0.4679
LSD (P=0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

TABLE 9: Effect of the interaction of species, seeding method, and tillage on visual ratings of turf and weed cover taken May 10, July 22, and October 29, 1991, for plots established September, 1989. Each value is the mean of 4 replications.

		Seeding	May 10		July 22		October 29	
Species	Tillage	Method	Turf	Weed	Turf	Weed	Turf	Weed
			(----------percent cover----------)					
hard fescue	disk	cultipacker	86	19	74	10	75	15
hard fescue	disk	drop	92	11	85	4	78	12
hard fescue	none	cultipacker	73	29	83	7	77	12
hard fescue	none	drop	76	23	84	9	75	16
tall fescue	disk	cultipacker	96	3	53	1	83	2
tall fescue	disk	drop	97	1	54	1	83	2
tall fescue	none	cultipacker	94	2	54	1	83	5
tall fescue	none	drop	95	2	51	1	77	5
Probability Level (P)			0.8817	1.0000	0.0183	0.4640	1.0000	1.0000
LSD (P=0.05)			n.s.	n.s.	6	n.s.	n.s.	n.s.

TABLE 10: Variety name and species of the grasses established at the Horticulture Research Farm, May 8, 1990.

Variety	Species	Variety	Species
1. Dover	chewings fescue	14. Spartan	hard fescue
2. Jamestown	chewings fescue	15. SR 3000	hard fescue
3. Shadow	chewings fescue	16. SR 3100	hard fescue
4. SHE	chewings fescue	17. Dawson	slender creeping fescue
5. SR 5000	chewings fescue	18. Bargena	creeping red fescue
6. Victory	chewings fescue	19. Ensylva	creeping red fescue
7. Wilma	chewings fescue	20. Jasper	creeping red fescue
8. AUE	hard fescue	21. Pennlawn	creeping red fescue
9. Biljart	hard fescue	22. Bighorn	sheep fescue
10. Crystal	hard fescue	23. Covar	sheep fescue
11. Durar	hard fescue	24. MX-86	sheep fescue
12. HF 8250	hard fescue	25. Lex86	perennial ryegrass
13. Reliant	hard fescue	26. Barclay	perennial ryegrass

month from April through October.

TABLE 11: Visual ratings of total vegetative (living and dormant/dead) cover, turf cover, and weed cover taken in 1990 and 1991 for plots established May 8, 1990. The interaction between turf variety and maintenance level was significant for turf cover rating for August 4, 1991, and values for both high and low maintenance levels are reported. These values are the mean of three replications. All other values are averaged over maintenance levels and are the mean of six replications.

							August 4, 1991						
	June 26, 1990		May 13, 1991				Turf	Turf		October 9, 1991		
No. Variety	Turf	Weed	Total	Turf	Weed	Total	High	Low	Weed	Total	Turf	Weed
1. Dover	47	27	88	53	3	88	22	20	5	92	54	8
2. Jamestown	40	23	92	56	3	95	23	22	5	97	54	6
3. Shadow	27	20	88	48	5	89	23	23	6	91	55	10
4. SHE	43	17	93	52	3	94	23	23	6	97	57	8
5. SR 5000	43	13	90	53	2	95	20	22	4	97	56	10
6. Victory	50	20	93	49	3	94	28	27	7	96	58	8
7. Wilma	40	17	95	57	2	93	25	23	5	94	48	9
8. Aue	27	30	92	68	5	91	85	82	9	97	83	8
9. Biljart	33	33	87	58	8	93	77	73	8	97	80	6
10. Crystal	23	27	95	68	6	91	77	70	12	95	77	13
11. Durar	23	37	81	63	6	95	58	53	16	97	46	9
12. HF 8250	17	27	96	70	4	96	87	80	11	95	82	10
13. Reliant	20	30	95	70	3	96	83	80	7	97	81	7
14. Spartan	20	23	89	66	2	92	87	83	4	95	78	6
15. SR 3000	20	27	87	63	3	90	80	75	3	94	83	5
16. SR 3100	10	27	91	66	5	92	83	80	9	95	78	10
17. Dawson	50	23	96	48	1	98	62	62	3	99	43	6
18. Bargena	63	13	91	53	2	93	62	58	5	94	61	6
19. Ensylva	43	30	89	48	2	94	68	67	2	96	51	4
20. Jasper	43	17	95	50	2	96	53	53	7	98	52	5
21. Pennlawn	53	13	97	49	1	95	62	58	2	99	42	3
22. Bighorn	33	23	94	68	5	96	87	88	6	96	62	6
23. Covar	27	23	86	67	14	89	18	17	21	89	58	8
24. MX-86	27	20	89	57	6	93	86	75	8	96	55	8
25. Lex86	83	03	80	29	2	74	20	20	4	74	49	4
26. Barclay	87	03	90	11	1	83	25	25	6	70	50	5
Probabillity Level (P)	0.0001	0.0001	0.1526	0.0001	0.0001	0.001	0.0165	0.0165	0.0001	0.0001	0.0001	0.2975
LSD (L=0.05)	19	11	n.s.	14	3	5	4	4	5	5	8	n.s.

RESULTS

The 1991 data was analyzed as a randomized complete block design with a split-block treatment arrangement, with variety and maintenance level as main effects. Results from all ratings are reported in Table 11. There was a significant interaction between variety and maintenance level for the August 4 turf cover rating. The effect of maintenance level was not significant for any rating. Both perennial ryegrass varieties established quickly in 1990. Of the fine fescues, chewings and red fescue varieties established faster than the hard and sheep fescue varieties. The ratings for May 13 indicate that all varieties had established well by spring of 1991, despite some low turf cover ratings for June 26, 1990. The stand density of the perennial ryegrass varieties decreased with time and were rated poorly in May and August of 1991, never exceeding a height of four inches either season. Despite low cover ratings, weed pressure in the ryegrass plots was very light, which suggests allelopathy from the perennial ryegrass. All of the fine fescue varieties provided almost complete vegetative cover in 1991. However the hard fescues, on average, provded a higher percentage of green turf cover later into the season in 1991 (Table 12). On October 9, the average green turf cover rating for the hard fescues is 76 percent, compared to 55 percent for chewings fescues, 43 percent for slender creeping fescue, 52 percent for creeping red fescues, and 58 percent for sheep fescues. 'Durar' was notable among the hard fescues for its longer foliage, lighter color, and reduced density.

TABLE 12: Average turf cover ratings for October 9, 1991, summarized by fine fescue species.

Species	Number of Varieties in Test	Percent Cover, October 9
hard fescue	9	76
chewings fescue	7	55
slender creeping fescue	1	43
creeping red fescue	4	52
sheep fescue	3	58

CONCLUSIONS

The perennial ryegrasses established faster than the fine fescues, but decreased in stand density with time. Even at reduced stand density they were still very competetive with weeds, probably through an alleleopathic effect. The fine fescues, though they established slower, all produced a very high total vegetative cover and were very competitive with weeds.

6. Effects of Mowing Frequency on Varieties of Fine Fescue and Tall Fescue Maintained under Roadside Conditions, PSU LMRC

MATERIALS AND METHODS

This study, designed to evaluate the effects of mowing frequency on varieties of fine fescue and tall fescue was established June 1, 1990, at the Landscape Management Research Center. Sixteen fine fescue varieties and five tall fescue varieties (Table 12) were drop seeded onto 5 by 30 ft plots arranged in a randomized complete block design with three replications. The site was prepared by treating the existing vegetation with 3 lb ae/acre of glyphosate, mowing the killed vegetation, and scarifying the seedbed with two passes with a flail mower equipped with dethatching blades. The study area was treated with 0.5 lb ae/acre of 2,4-D on July 16, to control wild buckwheat (*Polygonum convolvulus*), and was mowed on July 25 and October 16 to remove tall weeds. Mowing frequency treatments were initiated in 1991, with 5 by 10 ft sub-plots being mowed either once, twice, or three times during the season. The dates for the different mowing frequencies were, once-May 31, twice-May 31 and November 7, and three times-May 31, July 25, and November 7. The plots were mowed with a flail mower set at 3.5 in. Visual ratings were taken for turf cover and weed cover on December 17, 1990; total cover (alive and dead/dormant turf cover), green turf cover, and weed cover on May 12 and July 1,1991; and turf and weed cover on November 7, 1991. All ratings were taken on the original 5 by 30 ft plots. This

year,1991, was extremely hot and dry in the test area, with below average rainfall every month from April through October. Rating of the mowing frequency sub-plots will not begin until 1992.

RESULTS

The season-end ratings from 1990 and 1991 indicate that under the conditions of this study, all varieties established well, and persisted. Though some of the hard and sheep fescue varieties had higher weed ratings the year of seeding, by November 7, 1991 they were well enough established to compete with the weeds

7. Performance of Fine Fescue Varieties under Low Maintenance Conditions, PSU LMRC

MATERIALS AND METHODS

A test evaluating the performance of 93 fine fescue varieties under low maintenance conditions was established as part of the National Turfgrass Evaluation Program on October 5, 1990, at the Landscape Management Research Center, University Park, PA. For the purposes of this test, low maintenance is defined as mowing 4 to 6 times per season at 3 to 4 in, applying no more than 1.0 lb of N/1000 sq. ft per year, no irrigation, and application of herbicides only when weed pressure is severe. The test area is mapped as a Hagerstown silt loam, and had a four year old stand of alfalfa on it prior to establishment. The alfalfa was treated with glyphosate; 2,4-D; and dicamba; at 1.5, 1.0, and 0.5 lb ae/acre, respectively. The area was rototilled, firmed with a Gill tool, and hand raked. The seed was dropped onto 4 by 6 ft plots arranged in a randomized complete block with three replications, starter fertilizer was applied at 0.7, 1.0, 0.2 lbs of N, P_2O_5, and K_2O/1000 sq. ft, respectively. The area was fertilized with 0.5 lb/1000 sq. ft of urea N on May 23, and October 23, 1991. The area was mowed at a height of 4 in with a rotary mower collecting clippings in late April and early May to remove shepherdspurse (*Capsella bursa-pastoris*) inflorescences, and on October 15. The area was mowed at 4 in with clippings returned in late August. This mowing frequency was lower than anticipated, due to the drought conditions experienced throughout the growing season. Average rainfall for the region was six inches below normal for April through October, and rainfall was below average for every month in that period. A treatment of 2,4-D and dicamba at 0.25 plus 0.12 lb ae/acre was applied May 29 for control of broadleaf weeds. The area did not receive irrigation. Visual ratings of percent turf cover and weed cover were taken May 23; percent turf cover, and turf color and quality were rated June 27; canopy height and blade length measurements were taken October 2, and turf color and quality were rated October 22, 1991.

RESULTS

The results, reported in Table 13, are ranked by average turf quality, and show that the hard fescues were providing the best initial performance under the conditions of this test. The high percent turf cover provided on May 23 and June 27 provided by almost all of the fine fescues indicates that though their ratings as turfgrasses may be low, they still have considerable value as cover crops.

TABLE 13: Visual ratings of percent turf and weed cover on December 17, 1990, and total vegetative (living and dormant/dead) cover, green turf cover, and weed cover taken on May 12, July 1, and November 7, 1991, for plots established June 1, 1990.

		Dec. 17, 1990		May 12			July 1			November 7	
Variety	Species	Turf	Weed	Total	Turf	Weed	Total	Turf	Weed	Turf	Weed
		(----------percent cover----------)									
1. Jamestown	chewings	97	3	98	78	8	100	73	10	95	2
2. Victory	chewings	97	3	98	77	7	100	73	7	96	2
3. AUE	hard	92	8	99	70	27	100	77	30	94	5
4. Aurora	hard	88	12	97	73	27	90	73	22	95	4
5. Durar	hard	72	27	97	73	33	100	58	33	92	7
6. Reliant	hard	94	6	100	83	10	100	87	7	97	2
7. Spartan	hard	97	3	100	83	8	100	83	8	96	3
8. SR 3000	hard	76	22	95	75	25	100	73	28	94	5
9. SR 3100	hard	85	15	98	77	13	95	73	17	94	3
10. Dawson	slender creeping	98	2	99	80	3	97	83	5	95	2
11. Jasper	creeping red	97	2	99	77	6	100	75	6	96	3
12. SHAE	creeping red	97	2	99	78	2	100	80	7	95	2
13. Shademaster	creeping red	94	6	99	78	7	100	82	7	93	4
14. Bighorn	sheep	88	12	96	63	33	97	73	17	95	3
15. Covar	sheep	75	25	92	65	40	93	57	42	91	6
16. MX 86	sheep	82	17	95	67	25	100	77	18	93	5
17. Murietta	tall	93	4	94	78	8	97	75	7	91	3
18. Rebel II	tall	95	2	94	80	8	97	68	20	91	3
19. Rebel Jr.	tall	96	3	96	85	3	97	75	5	91	3
20. Shortstop	tall	95	2	94	77	9	93	73	7	91	2
21. Silverado	tall	95	2	94	82	7	93	75	8	91	3
Probability Level (P)		0.0010	0.0002	0.0752	0.0153	0.0001	0.3465	0.0605	0.0001	0.0178	0.0775
LSD (P=0.05)		14	12	n.s.	11	12	n.s.	n.s.	14	4	n.s.

8. Performance of Kentucky Bluegrass Varieties under Low Maintenance Conditions, PSU LMRC

MATERIALS AND METHODS

A test evaluating the performance of 63 Kentucky bluegrass varieties under low maintenance conditions was established as part of the National Turfgrass Evaluation Program on October 3, 1990, at the Landscape Management Research Center, University Park, PA. For the purposes of this test, low maintenance is defined as mowing 4 to 6 times per season at 3 to 4 in, applying no more than 1.0 lb of N/1000 sq. ft per year, no irrigation, and application of herbicides only when weed pressure is severe. The test area is mapped as a Hagerstown silt loam, and had a four year old stand of alfalfa on it prior to establishment. The alfalfa was treated with glyphosate, 2,4-D, and dicamba, at 1.5, 1.0, and 0.5 lb ae/acre, respectively. The area was rototilled, firmed with a Gill tool, and hand raked. The seed was dropped onto 4 by 6 ft plots arranged in a randomized complete block with three replications, starter fertilizer was applied at 0.7, 1.0, and 0.2 lbs of N, P_2O_5, and K_2O/1000 sq. ft, respectively. The area was fertilized with 0.5 lb/1000 sq. ft of urea N on May 23, and October 23, 1991. The area was mowed at a height of 4 in with a rotary mower collecting clippings in late April and early May to remove shepherdspurse (*Capsella bursa-pastoris*) inflorescences, and on October 15. This mowing frequency was lower than anticipated, due to the drought conditions experienced throughout the growing season. Average rainfall for the region was six inches below normal for April through October, and rainfall was below average for every month in that period. The area was mowed at 4 in with clippings returned in late August. A treatment of 2,4-D and dicamba at 0.25 plus 0.12 lb ae/acre was applied May 29 for control of broadleaf weeds. The area did not receive irrigation. Visual ratings of percent turf cover and weed cover were taken May 21; percent turf cover, and turf color and quality were rated June 28; visual ratings of leaf spot (*Drechslera poae*) severity were taken September 5; canopy height measurements were taken October 1, and turf color and quality were rated October 23, 1991. These results are reported in Table 14.

TABLE 14: Performance ratings for fine fescue cultivars taken May 23, June 27, October 2, and October 22, for plots established October 6, 1990. Visual ratings were taken for percent cover, and turf color and quality. Color and quality were rated on a 0 to 9 scale, with 9=best. Each value is the mean of three replications.

		May 23		June 27			October 2		October 22		
Entry	Species	Turf Cover	Weed Cover	Turf Cover	Turf Color	Turf Quality	Canopy Height	Blade Length	Turf Color	Turf Quality	Average Quality
		(%)	(%)	(%)	(0-9)	(0-9)	(in)	(in)	(0-9)	(0-9)	(0-9)
Aurora	Hard	93	14	88	4.0	5.3	6.7	6.7	7.3	7.0	6.2
Silvana	Hard	91	16	92	4.3	5.3	6.7	6.7	7.7	6.7	6.0
HF 9032	Hard	94	15	95	4.0	6.0	6.7	7.0	7.3	6.0	6.0
Serra	Hard	94	13	93	3.7	5.7	6.3	7.7	7.7	6.0	5.9
SR 3000	Hard	94	17	93	4.0	5.0	6.3	7.3	7.7	6.7	5.9
HF 8250	Hard	94	17	93	3.3	5.0	6.3	7.7	8.0	6.7	5.9

(continued)

TABLE 14: (cont.) Performance ratings for fine fescue cultivars taken May 23, June 27, October 2, and October 22, for plots established October 6, 1990. Visual ratings were taken for percent cover, and turf color and quality. Color and quality were rated on a 0 to 9 scale, with 9=best. Each value is the mean of three replications.

		May 23		June 27			October 2		October 22		
Entry	Species	Turf Cover	Weed Cover	Turf Cover	Turf Color	Turf Quality	Canopy Height	Blade Length	Turf Color	Turf Quality	Average Quality
		(%)	(%)	(%)	(0-9)	(0-9)	(in)	(in)	(0-9)	(0-9)	(0-9)
BAR Fo 9A2	Hard	94	14	93	4.3	5.3	6.0	6.3	7.7	6.3	5.8
Eureka	Hard	95	15	92	4.3	5.7	5.0	6.7	7.0	5.7	5.7
Melody	Hard	92	16	92	5.7	5.3	7.0	8.0	7.7	6.0	5.7
PST-4AG	Hard	92	15	90	4.7	5.3	7.3	7.7	7.3	6.0	5.7
Reliant	Hard	95	18	93	4.0	5.3	6.7	8.0	8.0	6.0	5.7
Bighorn	Sheep	89	18	90	4.7	5.0	6.0	6.3	8.0	6.0	5.5
Reliant E	Hard	92	19	88	4.3	4.7	7.0	7.7	8.0	6.3	5.5
Biljart	Hard	91	16	93	4.3	4.7	6.3	6.7	7.0	6.3	5.5
Spartan	Hard	93	13	95	3.7	5.0	7.3	8.7	7.3	6.0	5.5
PST-4HD	Hard	92	17	92	4.0	4.0	6.0	6.3	7.7	6.7	5.4
Valda	Hard	93	14	92	5.0	4.7	7.0	7.3	7.7	6.0	5.4
SR 3100	Hard	90	21	82	5.0	4.3	6.0	6.0	8.0	6.0	5.2
PST-AUE	Hard	87	21	85	4.3	4.0	6.3	7.3	7.3	6.3	5.2
MX 86	Sheep	89	17	92	3.3	4.0	6.7	7.0	7.3	6.0	5.0
Scaldis	Hard	91	16	90	4.0	3.7	6.0	7.0	7.7	6.3	5.0
Attila	Hard	89	16	82	5.3	3.7	5.7	6.3	7.3	6.3	5.0
BAR Fr 9P	Slender Creeping	93	13	90	4.0	4.7	7.7	8.3	7.0	5.3	5.0
Bargreen	Chewings	93	14	92	3.7	4.3	5.3	6.3	7.3	5.7	5.0
HF 102	Slender Creeping	94	12	88	4.0	5.0	5.7	6.7	6.0	5.0	5.0
Jamestown	Chewings	94	12	93	4.0	5.0	6.7	7.3	7.3	5.0	5.0
NK 82492	Chewings	93	14	87	4.7	4.7	5.3	6.7	7.0	5.0	4.9
Molinda	Chewings	92	16	90	4.0	4.7	6.3	6.7	7.7	5.0	4.9
Barcrown	Slender Creeping	94	15	93	4.0	4.7	7.0	8.3	6.7	5.0	4.9
Jamestown II	Chewings	92	12	87	4.0	4.7	7.3	7.7	7.0	5.0	4.9
Shadow	Chewings	93	12	92	3.7	4.3	6.7	8.0	7.7	5.3	4.8
Barnica	Chewings	92	13	83	3.7	4.3	6.3	6.7	7.7	5.0	4.7
Bar Fr 9F	Chewings	92	17	87	4.3	4.0	6.0	6.7	8.0	5.3	4.7
Shademaster	Creeping Red	92	12	85	3.3	4.3	7.0	9.3	7.0	5.0	4.7
Frt-30149	Slender Creeping	88	17	82	5.0	4.3	7.0	8.0	7.0	5.0	4.7
Waldorf	Chewings	92	17	90	4.0	4.3	6.0	6.7	7.0	5.0	4.7
Marker	Slender Creeping	89	15	78	5.7	4.0	5.3	6.0	7.7	5.3	4.7
Puma	Chewings	93	13	92	3.0	4.3	6.3	6.3	7.7	5.0	4.7
Barlotte	Slender Creeping	96	11	93	3.0	4.3	5.7	8.3	6.0	4.7	4.5
PST-4CD	Chewings	89	14	82	3.7	3.7	6.7	8.0	7.3	5.3	4.5
Longfellow	Chewings	92	12	85	4.0	4.3	6.3	7.7	7.3	4.7	4.5
SR 5000	Chewings	94	12	90	2.3	4.0	6.7	7.7	7.3	4.7	4.4
PST-SHE	Chewings	90	15	85	4.3	3.7	6.0	7.7	7.7	5.0	4.4
HF 112	Chewings	92	14	82	3.3	4.0	6.0	7.0	7.0	4.7	4.4
Belmont	Chewings	91	13	87	4.0	3.7	6.0	7.7	7.3	5.0	4.4
Capitol	Chewings	94	12	88	4.0	4.0	6.7	7.0	7.7	4.7	4.4
Cindy	Creeping Red	93	13	82	3.3	4.0	7.0	8.0	7.0	4.7	4.4
Wilma	Chewings	90	17	78	4.0	3.7	7.0	7.0	7.0	5.0	4.4
Banner	Chewings	91	17	80	3.7	3.7	6.3	7.7	7.3	5.0	4.4
89.LKR	Chewings	93	16	90	4.0	4.0	6.7	7.3	7.7	4.7	4.4
Vista	Creeping Red	94	11	87	3.3	4.3	7.3	9.7	7.0	4.3	4.3
Herald	Creeping Red	91	12	85	3.3	4.3	7.3	8.7	6.7	4.3	4.3
ZW 42-148	Creeping Red	93	11	83	3.7	3.7	9.3	10.0	7.0	4.7	4.2
Trophy	Chewings	91	14	82	3.7	3.7	6.0	7.3	7.0	4.7	4.2
Ensylva	Creeping Red	92	14	90	4.0	3.7	6.0	6.7	7.0	4.7	4.2
LD 3488	Slender Creeping	89	13	82	4.7	3.7	7.7	8.7	7.0	4.7	4.2
WW Rs 138	Creeping Red	93	13	85	3.7	4.3	7.7	8.7	7.0	4.0	4.2
JMB-89	Chewings	91	12	88	3.0	4.0	6.3	6.7	7.0	4.3	4.2
PST-4FE	Chewings	82	15	68	4.3	3.0	6.7	7.3	7.7	5.3	4.2
PST-4C8	Creeping Red	91	12	83	4.3	4.3	7.3	8.3	7.0	4.0	4.2

(continued)

TABLE 14: (cont.) Performance ratings for fine fescue cultivars taken May 23, June 27, October 2, and October 22, for plots established October 6, 1990. Visual ratings were taken for percent cover, and turf color and quality. Color and quality were rated on a 0 to 9 scale, with 9=best. Each value is the mean of three replications.

		May 23		June 27			October 2		October 22		
Entry	Species	Turf Cover	Weed Cover	Turf Cover	Turf Color	Turf Quality	Canopy Height	Blade Length	Turf Color	Turf Quality	Average Quality
		(%)	(%)	(%)	(0-9)	(0-9)	(in)	(in)	(0-9)	(0-9)	(0-9)
Scarlet	Chewings	88	13	82	4.0	4.0	6.0	7.0	8.0	4.3	4.2
Southport	Chewings	88	15	82	3.3	4.0	6.7	7.7	7.3	4.3	4.2
Salem	Creeping Red	88	12	78	3.7	4.0	8.7	9.0	7.0	4.3	4.2
Rainbow	Chewings	91	13	87	3.7	4.0	5.7	6.3	7.7	4.3	4.2
Claudia	Creeping Red	93	12	82	3.3	4.0	7.3	8.7	7.0	4.3	4.2
ERG 1143	Chewings	89	15	83	3.7	4.0	5.3	5.3	7.7	4.3	4.2
Camaro	Chewings	89	14	80	3.7	3.3	5.7	6.7	7.3	4.7	4.0
WW Rs 143	Creeping Red	95	12	88	3.0	4.0	7.7	9.0	6.3	4.0	4.0
PST-43F	Creeping Red	91	11	82	3.3	3.7	8.7	10.0	7.3	4.3	4.0
Flyer	Creeping Red	92	15	88	3.3	3.7	7.7	10.0	7.0	4.3	4.0
Mary	Chewings	94	12	93	3.3	4.3	5.7	6.7	7.3	3.7	4.0
Jasper	Creeping Red	91	12	88	4.0	4.0	8.7	8.7	7.0	4.0	4.0
Koket	Chewings	82	20	67	4.7	3.0	7.7	8.0	7.3	5.0	4.0
LD 3485	Chewings	90	11	87	3.0	3.7	5.3	6.0	7.3	4.3	4.0
Raymond	Chewings	92	11	90	3.3	4.7	7.0	7.3	7.7	3.0	3.9
HF 138	Hard	87	16	73	4.7	3.3	5.3	6.3	6.7	4.3	3.8
OFI 89-200	Chewings	90	13	85	3.3	3.3	5.7	6.0	7.3	4.3	3.8
Elanor	Creeping Red	90	12	78	3.7	3.7	8.7	9.3	6.7	3.7	3.7
Enjoy	Chewings	92	12	90	4.0	3.7	6.0	6.3	7.3	3.7	3.7
PST-4NI	Creeping Red	93	13	85	3.3	4.0	7.3	8.7	6.7	3.3	3.7
BAR Fr8RC3	Creeping Red	92	12	87	3.0	4.0	7.3	9.3	7.0	3.3	3.7
LD 3414	Creeping Red	86	12	77	4.0	4.0	6.3	7.0	7.0	3.3	3.7
LD 3438	Creeping Red	92	13	85	4.3	4.0	8.0	8.0	7.0	3.3	3.7
PST-4R3	Creeping Red	90	12	72	4.7	3.3	8.3	10.7	7.0	3.7	3.5
Belvedere	Creeping Red	91	14	78	4.0	3.3	7.7	9.3	7.0	3.7	3.5
Bargena	Creeping Red	93	10	88	3.0	3.3	7.0	10.0	6.7	3.7	3.5
Franklin	Creeping Red	91	11	83	3.0	3.0	8.3	9.7	7.0	3.7	3.4
Boreal	Creeping Red	93	10	83	2.7	3.7	7.7	9.7	6.7	3.0	3.4
Atlanta	Chewings	82	16	63	4.3	2.3	5.7	6.3	7.3	4.3	3.3
Sylvester	Creeping Red	83	15	63	4.0	2.7	8.0	9.0	7.0	3.3	3.0
WW Rs 130	Creeping Red	80	17	60	5.7	2.7	9.3	11.0	7.0	3.3	3.0
Dawson	Slender Creeping	42	26	42	5.7	2.0	7.3	8.0	6.7	4.0	3.0
Barreppo	Hard	45	30	40	6.0	1.3	5.7	5.7	8.3	4.0	2.7
LSD (P=0.05)		9	5	10	1.1	1.2	1.6	1.6	0.7	1.3	- - -

TABLE 15: Performance ratings of Kentucky bluegrass cultivars evaluated May 21, June 28, September 5, and October 1 and 23, 1991. Visual ratings were taken for percent cover, turf color and quality, and leaf spot severity. Color and quality were rated on a 0 to 9 scale, with 9=best, and leaf spot severity was rated on a 0 to 10 scale, with 10=100 percent of the plot area affected.

	May 21		June 28			Sept 5	Oct 1	October 23		
Entry	Turf Cover	Turf Cover	Turf Cover	Turf Color	Turf Quality	L. Spot Severity	Canopy Height	Turf Color	Turf Quality	Average Quality
	(%)	(%)	(%)	(0-9)	(0-9)	(0-9)	(in)	(0-9)	(0-9)	(0-9)
Victa	90	20	92	4.7	5.0	0.2	7.3	7.0	5.3	5.2
Monopoly	95	14	95	3.3	4.7	0.0	7.0	6.0	5.3	5.0
BAR VB 7037	88	18	93	4.0	5.0	1.8	6.7	6.7	5.0	5.0
BAR VB 895	92	16	95	2.7	5.0	1.3	7.3	6.0	4.7	4.9

(continued)

TABLE 15: (cont.) Performance ratings of Kentucky bluegrass cultivars evaluated May 21, June 28, September 5, and October 1 and 23, 1991. Visual ratings were taken for percent cover, turf color and quality, and leaf spot severity. Color and quality were rated on a 0 to 9 scale, with 9=best, and leaf spot severity was rated on a 0 to 10 scale, with 10=100 percent of the plot area affected.

	May 21		June 28			Sept 5	Oct 1	October 23		
Entry	Turf Cover	Turf Cover	Turf Cover	Turf Color	Turf Quality	L. Spot Severity	Canopy Height	Turf Color	Turf Quality	Average Quality
	(%)	(%)	(%)	(0-9)	(0-9)	(0-9)	(in)	(0-9)	(0-9)	(0-9)
Bronco	92	16	95	3.7	5.0	0.2	7.7	6.0	4.7	4.9
PST-C-303	89	18	95	3.7	4.7	0.7	6.3	7.0	5.0	4.9
GEN-RSP	88	16	88	3.7	4.3	0.7	5.0	6.7	5.3	4.8
Voyager	93	16	95	3.3	4.3	1.3	6.7	7.0	5.3	4.8
Fortuna	88	21	93	5.0	4.7	0.0	6.3	7.0	4.7	4.7
Barmax	96	15	95	2.3	5.0	0.3	7.7	6.0	4.3	4.7
Crest	90	18	92	4.3	4.3	0.8	6.0	7.0	5.0	4.7
J-229	86	15	87	4.0	4.3	0.5	6.0	6.0	5.0	4.7
NJIC	83	14	85	3.7	4.0	1.7	6.0	7.0	5.0	4.5
Suffolk	92	17	93	3.3	4.7	0.5	7.0	6.3	4.3	4.5
BAR VB 13-2	84	16	88	3.7	4.3	1.5	7.0	6.0	4.7	4.5
BAR VB 1169	85	18	88	4.0	3.7	0.2	6.0	7.0	5.3	4.5
South Dakota Certified	88	18	93	3.7	5.0	2.5	7.0	7.0	4.0	4.5
Ba 74-017	90	17	90	4.3	3.7	0.3	4.3	7.3	5.0	4.4
ISI-21	87	21	93	3.0	4.0	2.2	6.0	6.7	4.7	4.4
Cynthia	88	17	92	2.7	3.7	0.8	5.7	7.0	5.0	4.4
798	87	18	80	5.0	3.7	0.7	5.7	8.0	5.0	4.4
Opal	83	15	83	4.7	3.7	1.5	5.7	7.0	5.0	4.4
Chelsea	87	22	87	6.0	3.7	1.3	7.7	7.0	5.0	4.4
Kenblue	89	16	88	3.0	4.0	0.5	6.7	7.0	4.7	4.4
Barzan	88	18	95	3.7	4.3	0.2	7.3	6.3	4.3	4.3
Miracle	87	23	93	5.3	4.3	1.5	6.7	6.7	4.3	4.3
Ram-1	87	16	88	4.3	4.3	0.2	6.0	7.0	4.3	4.3
Unknown	87	21	92	4.7	4.3	0.5	5.7	7.0	4.3	4.3
Haga	87	15	92	3.0	4.3	1.0	7.0	6.3	4.3	4.3
Alene	91	18	95	2.3	4.3	2.5	7.7	6.3	4.3	4.3
MN 2405	88	16	95	3.0	4.7	1.8	6.0	7.0	3.7	4.2
J-386	85	16	85	3.7	3.7	0.8	6.3	7.0	4.7	4.2
Gnome	87	18	87	4.7	3.7	0.5	5.3	6.7	4.7	4.2
ZPS-84-749	86	14	87	4.0	4.0	0.5	6.3	7.0	4.3	4.2
Livingston	85	16	85	4.0	4.0	0.3	6.3	7.0	4.3	4.2
PST-A7-111	86	17	93	3.3	4.0	2.0	7.0	7.0	4.3	4.2
H76-1034	88	17	92	3.0	4.0	0.7	7.0	6.0	4.3	4.2
Merit	85	17	88	4.7	3.3	0.3	5.3	7.0	4.7	4.0
Park	88	14	93	2.0	4.7	2.5	7.0	6.3	3.3	4.0
Barsweet	87	18	85	4.0	3.7	0.0	5.0	7.0	4.3	4.0
Bartitia	90	16	92	3.7	4.0	0.0	5.7	6.3	4.0	4.0
NE 80-47	87	21	92	4.0	4.0	0.3	5.0	7.0	4.0	4.0
PST-YQ	86	16	92	3.3	4.0	0.7	5.3	6.3	4.0	4.0
Destiny	82	21	85	5.7	4.0	0.2	6.7	7.0	4.0	4.0
NuStar	85	16	85	3.7	3.3	0.3	6.7	6.3	4.7	4.0
Cobalt	89	20	93	4.3	4.3	0.0	4.7	7.0	3.7	4.0
Kyosti	85	16	88	5.3	3.7	0.8	6.0	7.0	4.0	3.9
Baron	85	16	87	4.0	3.7	0.7	5.7	7.0	4.0	3.9

(continued)

TABLE 15: (cont.) Performance ratings of Kentucky bluegrass cultivars evaluated May 21, June 28, September 5, and October 1 and 23, 1991. Visual ratings were taken for percent cover, turf color and quality, and leaf spot severity. Color and quality were rated on a 0 to 9 scale, with 9=best, and leaf spot severity was rated on a 0 to 10 scale, with 10=100 percent of the plot area affected.

	May 21		June 28			Sept 5	Oct 1	October 23		
Entry	Turf Cover	Turf Cover	Turf Cover	Turf Color	Turf Quality	L. Spot Severity	Canopy Height	Turf Color	Turf Quality	Average Quality
	(%)	(%)	(%)	(0-9)	(0-9)	(0-9)	(in)	(0-9)	(0-9)	(0-9)
EVB 13.703	89	16	92	3.7	4.0	0.7	4.0	6.3	3.7	3.9
EVB 13.863	86	17	87	3.7	3.7	0.3	6.7	6.0	4.0	3.9
J-335	83	16	88	4.0	3.7	0.8	6.7	6.3	4.0	3.9
Sophia	83	18	85	4.3	3.3	0.5	7.3	7.0	4.3	3.8
PST-C-391	82	17	82	3.3	3.7	0.5	6.0	6.7	3.7	3.7
Liberty	86	18	85	4.3	3.7	0.3	5.3	6.7	3.7	3.7
Freedom	88	15	88	3.0	3.7	0.5	6.0	6.0	3.7	3.7
Midnight	81	18	78	4.7	3.3	0.2	3.3	8.0	4.0	3.7
SR 2000	79	20	85	4.0	3.3	0.7	5.0	7.0	4.0	3.7
PST-C-76	82	21	85	5.0	4.0	0.2	4.0	7.0	3.0	3.5
Washington	87	15	92	2.3	3.3	0.7	6.7	6.0	3.7	3.5
KWS Pp 13-2	83	20	87	5.0	3.7	2.3	7.3	7.0	3.3	3.5
Ba 78-376	87	14	88	2.3	3.7	2.2	8.0	6.3	3.0	3.4
Amazon	60	21	67	5.0	2.7	0.3	4.3	7.0	3.7	3.2
Merion	30	25	47	4.7	1.3	0.0	4.0	7.0	2.7	2.0
LSD (P=0.05)	10	4	11	0.9	1.2	0.9	1.7	0.5	1.1	- - -

PLANT GROWTH REGULATOR STUDIES

Five studies evaluating plant growth regulators for use on low maintenance turf were completed in 1991.

1. Effect of Spray Adjuvants on PGR Activity on Tall Fescue - five spray adjuvants were added to each of two PGR treatments to determine their effects on the activity of the PGR's.
2. Evaluation of PGR Combinations on Tall Fescue - recommended treatments were compared with untried treatments.
3. Effect of UAN on the Activity of PGR Combinations on Tall Fescue - three rates of liquid nitrogen solution were added to three PGR treatments applied to tall fescue.
4. Effect of Increasing Rates of UAN on the Activity of Embark plus Telar on Tall Fescue - 12 incremental rates of UAN were added to Embark plus Telar to identify rates that could lead to injury observed in previous studies.
5. Evaluation of CGA-163935 Combination Treatments Applied to Tall Fescue - CGA-163935, an experimental PGR, was combined with Embark, Telar, Escort, and Event, and applied to tall fescue.

The products used in 1991 PGR studies are listed in Table 1.

1. Effect of Spray Adjuvants on PGR Activity on Tall Fescue

There is a range of opinion among the practitioners of vegetation management about the activity of the various brands of spray adjuvants. This study was intended to evaluate different types of adjuvants for their effect on the activity of two PGR treatments applied pre-mow to tall fescue.

TABLE 1: Trade names, active ingredients, formulation, and manufacturer of products used in PGR research in 1991.

Product	Active Ingredients	Formulation	Manufacturer
Banvel	dicamba	4 S	Sandoz Crop Protection Co.
CGA-163935	experimental	2 EC	CIBA-GEIGY Corporation
CideKick II	adjuvant	- - -	JLB International Chemical Co.
Clean Cut	adjuvant	- - -	Arborchem Products, Inc.
Embark	mefluidide	2 S	PBI/Gordon Corporation
Escort	metsulfuron methyl	60 DG	E.I. DuPont de Nemours and Co.
Event	imazethapyr + imazapyr	1.46 S	American Cyanamid Company
HyGrade Plus	adjuvant	- - -	CWC Chemical Company
Telar	chlorsulfuron	75 DG	E.I. DuPont de Nemours and Co.
X-77	adjuvant	- - -	Valent Chemical Company

MATERIALS AND METHODS

This experiment was established May 3, 1991, at the Penn State Landscape Management Research Center. Two PGR treatments, each sprayed with five different adjuvant treatments, were applied to unmowed 'Kentucky 31' tall fescue using a CO_2-powered, hand-held sprayer delivering 17 GPA at 30 psi, using Spraying Systems 8002 flat fan spray tips. All PGR treatments included 0.5 lb ae/acre of dicamba. Individual plots were 6 by 15 ft, arranged in a randomized complete block design with a split-plot treatment arrangement, with PGR treatment as the whole plot effect, and spray adjuvant as the sub-plot effect. The tall fescue was 3 to 8 in tall, and the apex of the inflorescence was extended up to 1 in from the base of the crown. The two PGR treatments were Embark at 24 oz/acre, and Embark plus Telar at 12 plus 0.25 oz/acre. The adjuvant treatments were none, X-77, Clean Cut, HyGrade Plus, and Cidekick II. Adjuvants were applied at the rate of 0.25% v/v. Visual ratings of turf color and turf quality were taken May 21. On June 5, canopy height was estimated by measuring the height at which a 1 ft diameter, 0.25 in thick particle-board disk was suspended after being dropped from a height of 3 ft. Clipping yields were taken June 13 on a dry weight basis, and July 16 on a fresh weight basis, with a rear-bag 20 in wide rotary mower set at a 3.5 in mowing height. The plots were not irrigated prior to June 13, and showed considerable drought stress. The plots were mowed at 3.5 in, then irrigated for three weeks with 0.75 in water/week prior to the July 16 clipping collection.

RESULTS

All PGR treatments provided excellent seedhead control. There was a significant interaction between PGR treatment and adjuvant for turf color on May 21 (Table 2). Turf color in plots treated with Embark alone was not significantly different from the untreated check, and was not affected by adjuvant. All plots treated with Embark plus Telar were rated significantly lower than the untreated check for turf color, and plots treated with Clean-Cut were rated significantly lower than those treated with Cidekick II. The effect of PGR treatment was not significant for any dependent variable. Adjuvant effects were significant for turf color, turf quality, and canopy height (Table 3). The untreated check was rated significantly higher for turf color than all treated plots. There was no significant difference in turf quality between the treated plots, and all treated plots had better turf quality than the untreated check, which had abundant seedheads and an uneven canopy due to unchecked growth. There was no significant difference in canopy height among the treated plots, and all treated plots were significantly shorter than the untreated check. The untreated check had the highest clipping yields on June 13, and there no significant differences in clipping yield on July 16.

TABLE 2: Turf color, turf quality, turf height, and clipping weights for plots treated May 3, 1991. Each value is the mean of 3 replications.

PGR	Application Rate	Spray Adjuvant	Turf Color May 21	Turf Quality May 21	Height June 5	Dry Weight June 13	Fresh Weight July 16
	(oz product/acre)		(0-9)[1/]	(0-9)[1/]	(in)[2/]	(lbs/plot)	(lbs/plot)
- - -		untreated check	8.0	4.7	11.8	2.44	1.48
Embark	24	none	7.7	6.3	8.2	1.55	2.23
Embark	24	X-77	7.7	6.0	9.5	1.74	1.67
Embark	24	Clean Cut	7.7	6.0	9.0	1.85	1.77
Embark	24	HyGrade Plus	7.7	6.3	8.8	1.51	2.10
Embark	24	Cidekick II	7.7	6.0	7.7	1.47	1.90
- - -		untreated check	8.0	4.3	12.0	1.54	1.79
Embark + Telar	12 + 0.25	none	6.3	6.7	5.9	0.70	1.67
Embark + Telar	12 + 0.25	X-77	6.3	6.7	5.7	0.73	1.69
Embark + Telar	12 + 0.25	Clean Cut	6.0	6.7	4.9	0.86	1.63
Embark + Telar	12 + 0.25	HyGrade Plus	6.3	6.7	5.4	1.27	1.77
Embark + Telar	12 + 0.25	Cidekick II	6.7	6.7	5.8	0.75	1.54
Significance Level (P)			0.0046	0.0601	0.1436	0.8207	0.3312
LSD(P=0.05)			0.6	n.s.	n.s.	n.s.	n.s.

1/ Turf color and quality were rated on a 0 to 9 scale, with '9' indicating ideal turf, '0' dead turf, and '5' the lowest acceptable rating.

2/ The height at which a 1 ft wide wooden disk was suspended when dropped from a height of 3 feet on to the canopy. Three measurements were taken for each plot.

TABLE 3: Turf color, turf quality, turf height, and clipping weights for adjuvant treatments averaged over two PGR treatments . Each value is the mean of 6 observations.

Spray adjuvant	Turf Color May 21	Turf Quality May 21	Height June 5	Dry Weight June13	Fresh Weight July 16
	(0-9)[1/]	(0-9)[1/]	(in)[2/]	(lbs/plot)	(lbs/plot)
untreated check	8.0	4.5	11.9	1.99	1.64
none	7.0	6.5	7.1	1.13	1.95
X-77	7.0	6.3	7.6	1.23	1.68
Clean Cut	6.8	6.3	7.0	1.35	1.70
HyGrade Plus	7.0	6.5	7.1	1.39	1.94
Cidekick II	7.2	6.3	6.7	1.11	1.72
Significance Level (P)	0.0001	0.0001	0.0001	0.0881	0.4656
LSD(P=0.05)	0.4	0.4	1.7	n.s.	n.s.

1/ Turf color and quality were rated on a 0 to 9 scale, with '9' indicating ideal turf, '0' dead turf, and '5' the lowest acceptable rating.

2/ The height at which a 1 ft wide wooden disk was suspended when dropped from a height of 3 feet on to the canopy. Three measurements were taken for each plot.

CONCLUSIONS

Due to the severe drought experienced during the course of this study, there was little expression of PGR effects. It is encouraging, however, that despite the stress imposed on the turf by the drought, the turf was not injured by the PGR treatments applied in this study, or any of the other studies conducted at this location. This suggests that the PGR combinations currently available for use on roadsides can be used with some assurance of turf safety, when properly applied.

2. Evaluation of PGR Combinations on Tall Fescue

The objective of this trial was to compare recommended PGR combinations with combinations that have not yet been evaluated.

MATERIALS AND METHODS

An experiment evaluating the activity of different plant growth regulator (PGR) treatments on unmowed tall fescue was established May 3, 1991, at the Penn State Landscape Management Research Center. The treatments (Table 4) included Embark alone, Embark plus Event, Embark plus Telar, three combinations of Embark plus Escort, Event plus Telar, and an untreated check. All PGR treatments included dicamba at 0.5 lb ae/acre. The treatments were applied with a CO_2-powered, hand-held boom delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan spray tips. Plots were 6 by 15 ft, arranged in randomized complete block design with three replications. Visual ratings of turf color and quality were taken May 21. Canopy height was estimated on June 5 by measuring the height at which a 1 ft diameter by 0.25 in thick wooden disk was suspended after being dropped from a height of 3 ft. Clipping yields were taken June 13 on a dry weight basis, and July 16 on a fresh weight basis. The plots were not irrigated prior to June 13, and showed considerable drought stress. The plots were mowed at 3.5 in, then irrigated for three weeks at 0.75 in water/week prior to the July 16 clipping collection.

RESULTS

Due the severe drought and the shallow soil in the study site, the turf showed a lack of vigor and differences between the treatments and the untreated check were not as pronounced as expected. There were very few seedheads produced in the check. Treatment effects were not significant for turf color and quality ratings. Canopy height for the untreated check was significantly higher than all PGR treatments, and canopy height for mefluidide alone was greater than all other PGR treatments. There was no significant treatment effect on clipping yields for June 13 or July 16.

TABLE 4: Visual ratings for turf color and quality, and measurements of canopy height and clipping yields for plots treated May 3, 1991. Each value is the mean of 3 replications.

Product	Application Rate	Turf Color May 21	Turf Quality May 21	Canopy Height June 5	Dry Weight June 13	Fresh Weight July 16
	(oz/acre)	(0-9)[1/]	(0-9)[1/]	(in)[2/]	(lbs/plot)	(lbs/plot)
Embark	24	7.3	7.3	5.3	0.81	1.34
Embark + Event	8 + 4	7.0	7.7	4.5	0.28	1.41
Embark + Telar	12 + 0.25	6.3	7.3	3.9	0.42	1.01
Embark + Escort	8 + 0.125	6.3	7.3	4.3	0.33	1.20
Embark + Escort	4 + 0.25	6.3	7.3	4.7	0.31	1.27

Embark + Escort	2 + 0.25	6.3	7.3	4.3	0.33	1.15
Event + Telar	4 + 0.25	6.3	7.3	4.3	0.26	1.01
untreated check	- - -	8.0	6.7	6.6	0.59	1.41
Significance Level (P)		0.0999	0.7895	0.0002	0.2300	0.2673
LSD (p=0.05)		n.s.	n.s.	0.8	n.s.	n.s.

1/ Turf color and quality were rated on a 0 to 9 scale, with '9' indicating ideal turf, '0' dead turf, and '5' the lowest acceptable rating.

2/ The height at which a 1 ft wide wooden disk was suspended when dropped from a height of 3 feet on to the canopy. Three measurements were taken for each plot.

CONCLUSIONS

As observed in the adjuvant study, the drought seemed to mask any PGR treatment effects. Like the adjuvant study, it is encouraging that none of the treatments in this study caused injury to turf, suggesting that even the Embark plus Escort treatments, which previous research indicates are more potentially injurious than the other combinations, were safe under conditions of stress to the turf. However, growth regulators are not recommended for application during drought, as drought itself is a very effective growth regulator.

3. Effect of UAN on the Activity of PGR Combinations on Tall Fescue

In a repeat of an experiment conducted in 1990, UAN (28% liquid nitrogen solution) was added at three rates to three PGR treatments to evaluate the effect of the added nitrogen on PGR activity.

MATERIALS AND METHODS

This experiment was established May 3, 1991, on unmowed tall fescue at the Penn State Landscape Management Research Center. An untreated check and three PGR treatments, Em

TABLE 5: Ratings for turf color and quality, and measurements of turf height and clipping yields for plots treated May 3, 1991. Each value is the mean of 9 observations.

Product	Application Rate	Turf Color May 21	Turf Quality May 21	Height June 5	Dry Weight June 13	Fresh Weight July 16
	(oz product/acre)	(0-9)[1/]	(0-9)[1/]	(in)[2/]	(lbs/plot)	(lbs/plot)
Embark	24	7.4	6.9	5.5	0.76	1.36
Embark + Telar	12 + 0.25	6.7	7.7	4.5	0.35	1.22
Embark + Event	8 + 4	7.1	8.1	4.4	0.32	1.48
Check	- - -	7.6	6.3	5.8	0.93	1.39
Significance Level(P)		0.0082	0.0001	0.0001	0.0001	0.3157
LSD (P=0.05)		0.5	0.5	0.4	0.16	n.s.

1/ Turf color and quality were rated on a 0 to 9 scale, with '9' indicating ideal turf, '0' dead turf, and '5' the lowest acceptable rating.

2/ The height at which a 1 ft wide wooden disk was suspended when dropped from a height of 3 feet on to the canopy. Three measurements were taken for each plot.

bark, Embark plus Event, and Embark plus Telar (Table 5); were applied with each of three rates of UAN, 0, 2.5, and 5 gallons/acre. Treatments were applied to 6 by 15 ft plots using a CO_2-powered, hand held boom delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan spray tips. The plots were arranged in a randomized complete design with a split-plot treatment arrangement and three replications. Visual ratings of turf color and quality were taken May 21. Canopy height was estimated on June 5 by measuring the height at which a 1 ft diameter by 0.25 in thick wooden disk was suspended after being dropped from a height of 3 ft. Clipping yields were taken June 13 on a dry weight basis, and July 16 on a fresh weight basis. The plots were not irrigated prior to June 13, and showed considerable drought stress. The plots were mowed at 3.5 in, then irrigated for three weeks at 0.75 in water/week prior to the July 16 clipping collection.

RESULTS

There was no interaction between PGR treatment and UAN rate. Seedhead pressure was very low in the study area and was not rated. There were significant PGR treatment effects for turf color,

turf quality, turf height, and clipping dry weights. The check plots and Embark alone received the highest color ratings, and the ratings for the check were significantly higher than those for Embark plus Event and Embark plus Telar. The check and the Embark alone plots displayed little growth suppression, and were rated significantly lower than the combination treatments for turf quality due to an uneven appearance, and were significantly taller, and produced more clippings on June 13. UAN application rate had a significant effect on turf color,

TABLE 6: Ratings for turf color and quality, and measurements of turf height and clipping yields for plots treated May 3, 1991. Each value is the mean of 12 observations.

UAN Application Rate	Turf Color May 21	Turf Quality May 21	Height June 5	Dry Weight June 13	Fresh Weight July 16
(gallons /acre)	(0-9)[1/]	(0-9)[1/]	(in)[2/]	(lbs/plot)	(lbs/plot)
0	6.9	7.1	4.9	0.57	1.32
2.5	7.3	7.3	5.1	0.6	1.31
5	7.3	7.3	5.1	0.6	1.45
Significance Level(P)	0.0055	0.6782	0.7192	0.8521	0.9187
LSD (P=0.05)	0.2	n.s.	n.s.	n.s.	n.s.

1/ Turf color and quality were rated on a 0 to 9 scale, with '9' indicating ideal turf, '0' dead turf, and '5' the lowest acceptable rating.

2/ The height at which a 1 ft wide wooden disk was suspended when dropped from a height of 3 feet on to the canopy. Three measurements were taken for each plot.

with the 2.5 and 5 gallon/acre treatments being rated better than the check (Table 6).

CONCLUSIONS

The interaction between Embark plus Telar and UAN rate in the 1990 study was not observed in this study. The drought may have masked any PGR effects that would have been observed under more desirable growing conditions. As in the previous studies reported, none of the PGR combinations injured the turf, despit the drought conditions.

4. Effect of Increasing Rates of UAN on the Activity of Embark plus Telar on Tall Fescue

In a 1990 experiment, application of UAN at 5 gallon/acre with Embark plus Telar caused discoloration not observed at UAN rates of 0 or 2.5 gallon/acre, or in other PGR treatments. This experiment was established to try to more precisely determine UAN rate that contributes to turf discoloration with Embark plus Telar treatments.

MATERIALS AND METHODS

This experiment was established May 3, 1991, at the Penn State Landscape Management Research Center. Treatments were applied to unmowed tall fescue using a CO_2-powered, hand-held boom delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan spray tips. Individual plots were 6 by 15 ft, arranged in a randomized complete block design with three replications. Embark plus Telar, at 12 plus 0.25 oz/acre was applied with UAN at rates of 2.5 to 7.5 gallons/acre (7.3 to 22 lb N/acre), in 0.5 gallon/acre increments (Table 7). Visual ratings of turf

TABLE 7: Ratings for turf color and quality, and measurements of turf height and clipping yields for plots treated May 3, 1991. Each value is the mean of 3 replications.

Product	UAN Application Rate	Turf Color May 21	Turf Quality May 21	Height June 5	Dry Weight June 13	Fresh Weight July 16
	(gallons/acre)	(0-9)[1/]	(0-9)[1/]	(in)[2/]	(lbs/plot)	(lbs/plot)
Embark + Telar	2.5	7.0	8.0	4.3	0.23	0.71
Embark + Telar	3.0	7.0	8.0	4.4	0.31	0.96
Embark + Telar	3.5	7.0	8.0	4.4	0.36	0.79
Embark + Telar	4.0	7.0	8.0	4.3	0.34	0.81
Embark + Telar	4.5	7.0	8.0	4.6	0.34	0.90
Embark + Telar	5.0	7.0	8.0	4.2	0.27	0.79
Embark + Telar	5.5	7.0	8.0	4.6	0.29	0.85
Embark + Telar	6.0	7.0	8.0	4.2	0.24	0.88
Embark + Telar	6.5	7.0	8.0	4.4	0.25	0.88
Embark + Telar	7.0	7.0	8.0	4.2	0.20	0.83
Embark + Telar	7.5	7.0	8.0	4.1	0.25	0.77
untreated check	- - -	8.0	7.0	6.4	0.81	1.13
Significance Level (P)		- - -	- - -	0.0001	0.0001	0.4941
LSD (P=0.05)		- - -	- - -	0.4	0.18	n.s.

1/ Turf color and quality were rated on a 0 to 9 scale, with '9' indicating ideal turf, '0' dead turf, and '5' the lowest acceptable rating.

2/ The height at which a 1 ft wide wooden disk was suspended when dropped from a height of 3 feet on to the canopy. Three measurements were taken for each plot.

color and quality were taken May 21. Canopy height was estimated on June 5 by measuring the height at which a 1 ft diameter by 0.25 in thick wooden disk was suspended after being dropped from a height of 3 ft. Clipping yields were taken June 13 on a dry weight basis, and July 16 on a fresh weight basis. Results of all data collected are reported in Table 7. The plots were not irrigated prior to June 13, and showed considerable drought stress. The plots were mowed at 3.5 in, then irrigated for three weeks at 0.75 in water/week prior to the July 16 clipping collection.

RESULTS

UAN rate did not affect the activity of Embark plus Telar on tall fescue under the conditions of this study. Turf in the untreated check was significantly taller and produced significantly more clippings on June 13.

CONCLUSIONS

This study, and the previous study reporting UAN effects on other PGR treatments, should be repeated in 1992 if we are going to make any conclusions about the effect of adding nitrogen to PGR treatments. The drought apparently masked the effects of the PGR treatments.

5. Evaluation of CGA-163935 Combination Treatments Applied to Tall Fescue

CGA-163935 is an experimental growth regulator that may be labelled in the near future. There is little information available about its activity in combination with other PGR's. The objective of this study was to screen CGA-163935 in combination with other PGR's.

MATERIALS AND METHODS

This trial was established May 3, 1991, at the Penn State Landscape Management Research Center. CGA-163935 was applied at 0, 12, and 24 oz/acre, as a 6 ft wide strip treatment across 6 by 18 ft plots treated with Embark, Event, Escort, and Telar, and a check (Table 9), resulting in 6 by 6 ft combination treatment plots in a randomized complete block design with a split-block treatment arrangement with three replications. Treatments were applied with a CO_2-powered, hand-held boom delivering 17 GPA at 30 psi with Spraying Systems 8002 flat fan spray tips. Canopy height was estimated on June 5 by measuring the height at which a 1 ft diameter by 0.25 in thick wooden disk was suspended after being dropped from a height of 3 ft. Clipping yields were taken July 16 on a fresh weight basis,. The plots were not irrigated prior to June 13, and showed considerable drought stress. The plots were mowed at 3.5 in, then irrigated for three weeks at 0.75 in water/week prior to the July 16 clipping collection.

RESULTS

There was no interaction between CGA-163935 and the other PGR's. The low rate of Embark and the untreated check had the highest canopies, and there was no difference in clipping weights on July 16. CGA-163935 at 12 and 24 oz/acre significantly reduced canopy height compared to the untreated plots, but had no effect on clipping weights on July 16 (Table 10).

CONCLUSIONS

Under the conditions of this study, CGA-163935 did not display any synergism or antagonism with other PGR's. However, this study should be repeated, as the drought conditions seemed to mask, or hinder the effect of all PGR treatments applied.

TABLE 8: Turf height and fresh clipping weights for plots treated May 3, 1991. Each value is the mean of 9 observations.

Product	Application Rate	Height June 5	Fresh Weight July 16
	(oz product/acre)	(in)	(lbs/plot)
untreated check	- - -	5.7	0.28
Embark	8	5.9	0.29
Embark	12	4.8	0.30
Embark	16	5.1	0.30
Event	4	4.9	0.26
Telar	0.4	4.4	0.26
Escort	0.2	4.9	0.29
Significance Level (P)		0.0268	0.5839
LSD (P=0.05)		0.8	n.s.

TABLE 9: Turf height and fresh clipping weights for plots treated May 3, 1991. Each value is the mean of 21 observations.

Product	Application Rate	Height June 5	Fresh Weight July 16
	(oz product/acre)	(in)	(lbs/plot)
CGA 163935	0	5.8	0.29
CGA 163935	12	5.0	0.28
CGA 163935	24	4.6	0.28
Significance Level (P)		0.0103	0.9484
LSD (P=0.05)		0.6	n.s.

HERBACEOUS WEED CONTROL STUDIES

In 1991 three studies were conducted evaluating various combinations, herbicides, and application timings for control of Canada thistle in roadside crownvetch.

1. Herbicide Screening Study for Control of Canada Thistle in Crownvetch - currently recommended treatments were compared to untried treatments.
2. Evaluation of Basagran plus Velpar Tank Mixes for Canada Thistle Control - tank mixes of Basagran and Velpar were compared to either product alone.
3. Effects of Application Timing on the Selectivity of Transline and Velpar for Control of Canada Thistle in Crownvetch - Transline and Velpar were evaluated for activity on thistle and crownvetch at four application timings.

The products used in herbaceous weed control studies in 1991 are listed in Table 1.

1. Herbicide Screening Study for Control of Canada Thistle in Crownvetch

Previously investigated products were compared with untried products for selective control of Canada thistle in crownvetch.

MATERIALS AND METHODS

This study was initiated on May 21, 1991 at the Park Avenue interchange of SR 322, near State College, PA, in a mixed stand of crownvetch and Canada thistle. Seven treatments were applied to Canada thistle in the late vegetative/early bud growth stage with a CO_2-powered, hand-held sprayer delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan spray tips. Individual plots were 6 by 18 ft, arranged in a randomized complete block design with three

TABLE 1: Trade name, active ingredient, formulation, and manufacturer of chemicals used for herbaceous weed control research in 1991.

Treatment	Active Ingredient	Formulation	Manufacturer
Basagran	bentazon	4 S	BASF
CGA 136872	primisulfuron	75 DF	CIBA-GEIGY Corporation
Classic	chlorimuron	75 DF	E.I. DuPont de Nemours & Co.
Event	imazethapyr + imazapyr	1.46 S	American Cyanamid Company
Penetrator	adjuvant	- - -	Helena Chemical
Transline	clopyralid	3 S	DowElanco
UAN	urea ammonium nitrate	28% Nitrogen	- - -
Velpar	hexazinone	2.0 S	E.I. DuPont de Nemours & Co.
X-77	adjuvant	- - -	Valent Chemical Company

TABLE 2: Herbicide application rates and per acre costs for thistle control in crownvetch

Treatment[1/]	Application Rate (oz product /acre)	Application Rate (lb ai/acre)	Treatment Cost (per/acre)
1. Velpar	64	1.0	$23.80
2. Transline	20	0.47	$35.31
3. Event	4	0.046	$8.59
4. Event	8	0.092	$17.18
5. CGA-136782	0.66	0.031	NA
6. Classic	1	0.047	$18.32
7. Basagran + UAN + Penetrator	24 + 128 + 32	0.75	$13.62
8. Untreated Check	- - -	- - -	- - -

[1/] Except for the Basagran treatment, all treatments included X-77 at 0.25% v/v

replications. The products, application rates, and material costs are listed in Table 2.

The study was visually rated July 9, 49 days after treatment (DAT), for injury to crownvetch and Canada thistle (Table 3). Crownvetch was rated on a 0 to 3 scale, with '0' being no injury, '1' slight injury, '2' moderate injury, and '3' severe injury. Canada thistle was rated on a 0 to 5 scale, with '0' indicating no injury, '1' slight injury, '2' moderate injury, '3' severe injury with stem survival likely, '4' severe injury with stem death likely, and '5' dead stems.

RESULTS

Velpar severely injured Canada thistle while only slightly injuring crownvetch, however some treated thistle stems exhibited axillary and basal regrowth, and new shoots were present in all plots. Transline completely controlled Canada thistle and crownvetch with almost no regrowth of either species. Canada thistle stems treated with CGA-136872, Classic, Event, or Basagran did not flower, but vigorous axillary regrowth was observed on most treated stems. This study was rated again on October 17 at which time Canada thistle regrowth was present in all plots.

CONCLUSIONS

Under the conditions of this study, Velpar provided the best performance. However, to date, the best results available have been suppression, rather than control of Canada thistle.

TABLE 3: Visual injury ratings for crownvetch and Canada Thistle taken on July 7 for treatments applied on May 21, 1991. Each value is the mean of three replications.

Product	Application Rate	Canada thistle Injury	Crownvetch Injury
	(oz product/acre)	(0-5)[1/]	(0-3)[2/]
1. Velpar	64	3.7	0.7
2. Transline	20	5.0	3.0
3. Event	4	1.3	0.7
4. Event	8	1.0	0.7
5. Rifle	0.66	2.0	1.3
6. Classic	1	2.0	2.0
7. Basagran + UAN + crop oil	24 + 128 + 32	2.3	0.5
8. untreated check	- - -	0.0	0.0
Significance Level (P)		0.0001	0.0001
LSD (P = 0.05)		0.9	0.7

1/ Canada thistle injury ratings: 0 = no injury, 1 = slight, 2 = moderate, 3 = severe with recovery likely, 4 = severe with recovery not likely, and 5 = dead.
2/ Crownvetch injury ratings: 0 = no injury, 1 = slight , 2 = moderate, and 3 = severe.

2. Evaluation of Basagran plus Velpar Tank Mixes for Canada Thistle Control

Combination treatments of Basagran and Velpar were evaluated in an effort to maintain or improve control of Canada thistle while improving the safety to crownvetch.

MATERIALS AND METHODS

This study was established on May 31, 1991, at the Park Avenue interchange of SR 322, near State College, PA, in a mixed stand of crownvetch and Canada thistle. Five treatments were applied to Canada thistle in the bud stage of growth with a CO_2-powered, hand held sprayer delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan spray tips. Individual plots were 6 by 18 ft arranged in a randomized complete block design with two replications. The products, application rates, and material costs are listed in Table 4

The study was visually rated July 9, 39 (DAT) for injury to crownvetch and Canada thistle (Table 5). Crownvetch was rated on a 0 to 3 scale, with '0' being no injury, '1' slight injury, '2' moderate injury, and '3' severe injury. Canada thistle was rated on a 0 to 5 scale, with '0' indicating no injury, '1' slight injury, '2' moderate injury, '3' severe injury with stem survival likely, '4' severe injury with stem death likely, and '5' dead stems.

TABLE 4: Herbicide application rates and per acre costs for thistle control in crownvetch

Products[1/]	Application Rate (oz product /acre)	Application Rate (lb ai/acre)	Treatment Cost (per/acre)
1. Velpar + X-77	64 + 0.25% v/v	1.0	$23.80
2. Basagran + UAN + crop oil	24 + 128 + 32	0.75 + 35.8	$13.62
3. Basagran + Velpar + crop oil	24 + 16 + 32	0.75 + 0.25	$18.75
4. Basagran + Velpar + crop oil	24 + 32 + 32	0.75 + 0.5	$24.67
5. Basagran + Velpar + crop oil	16 + 11 + 32	0.5 + 0.17	$13.42

1/ Velpar alone was mixed with X-77 at 0.25% v/v, all other treatments included Penetrator at 32 oz/acre

TABLE 5: Visual injury ratings for crownvetch and Canada thistle taken on July 7 for treatments applied on May 31, 1991. Each value is the mean of three replications.

Product	Application Rate	Canada Thistle Injury	Crownvetch Injury
	(oz product/acre)	(0-5)[1/]	(0-3)[2/]
1. Velpar	64	5.0	1.0
2. Basagran + UAN + crop oil	24 + 128 + 32	2.5	1.0

3. Basagran + Velpar + crop oil	24 + 16 + 32	4.5	1.0
4. Basagran + Velpar + crop oil	24 + 32 + 32	5.0	0.5
5. Basagran + Velpar + crop oil	16 + 11 + 32	4.0	0.0
Significance Level (P)		0.0122	0.648
LSD (P=0.05)		1.1	n.s.

1/ Canada thistle injury ratings: 0 = no injury, 1 = slight, 2 = moderate, 3 = severe with recovery likely, 4 = severe with recovery not likely, and 5 = dead
2/ Crownvetch injury ratings: 0 = no injury, 1 = slight, 2 = moderate, and 3 = severe

RESULTS

Combinations of Velpar and Basagran provided better Canada thistle control than Basagran alone. These combinations provided control equal to Velpar alone and were rated lower for crownvetch injury, but were not significantly different. This study was rated again on October 17, at which time Canada thistle regrowth was present in all plots.

CONCLUSIONS

The combination of Basagran and Velpar provided control equal to Velpar alone at a lower cost. Although injury to crownvetch was not significantly different between the combination treatments, this may be due to the relative lack of precision in the rating system for crownvetch. Crownvetch in the combination plots, particularly the lowest rate treatment, had a stemmier appearance than the crownvetch treated with Velpar alone, suggesting that the treated stems were not injured and continued to grow.

3. Effects of Application Timing on the Selectivity of Transline and Velpar for Control of Canada Thistle in Crownvetch

The objective of this study was to determine if application timing of Velpar or Transline has an effect on activity on Canada thistle and crownvetch.

MATERIALS AND METHODS

This study was established on May 7, 1991 at the Park Avenue interchange of SR 322, near State College, PA, in a mixed stand of crownvetch and Canada thistle. Two herbicide treatments were applied to Canada thistle at four different timings with a CO_2-powered, hand held sprayer delivering 17 GPA at 30 psi using Spraying Systems 8002 flat fan spray tips. Individual plots were 6 by 18 ft. arranged in a randomized complete block design with three replications. The products, application rates, application timings, and per acre treatment costs are listed in Table 6. Five weeks after each treatment was applied, the live and dead thistle plants in each plot were counted, and a percent mortality for Canada thistle was calculated.

RESULTS

There was no interaction between herbicide treatment and application timing. When aver

TABLE 6: Herbicide application rates and material costs for thistle control in crownvetch

Product	Date	Thistle Growth Stage	Application Rate (oz product /acre)	Application Rate (lb ai/acre)	Material Cost ($/acre)
1. Velpar	5/7	pre-bud	64	1.0	$23.80
2. Transline	5/7	pre-bud	20	0.47	$35.31
3. Velpar	5/21	late pre-bud	64	1.0	$23.80
4. Transline	5/21	late pre-bud	20	0.47	$35.31
5. Velpar	5/31	bud	64	1.0	$23.80
6. Transline	5/31	bud	20	0.47	$35.31
7. Velpar	6/13	bloom	64	1.0	$23.80
8. Transline	6/13	bloom	20	0.47	$35.31

aged over application timing, the effect of herbicide treatment on thistle mortality was not significant (Table 7). Both herbicide treatments provided control of treated thistle stems, but Transline severely injured crownvetch. When averaged over herbicide treatment, application timing did not significantly affect thistle mortality (Table 8).

CONCLUSIONS

Based on the results of this study, the window for application of either Velpar or Transline extends from as soon as enough foliage is present to spray, right up to bud stage. Alhough both herbicides were effective on bloom stage thistle, application prior to bloom is recommended to prevent any seed production. The rate of Transline used in this study, the highest label rate, was excessive. This herbicide warrants continued evaluation due to its extreme activity on Canada thistle. Even if rates cannot be found that are reasonably selective to crownvetch, it certainly deserves consideration for spot applications. Transline does not remain active in the soil as long as Velpar does at the rates used for thistle control, and may be a better alternative for spot treatment.

TABLE 7: Canada thistle mortality averaged over four application timings, rated five weeks after treatment. Each value is the mean of 12 observations.

Product	Application Rate	Canada thistle Mortality
	(oz product/acre)	(%)
Velpar	64	79
Transline	20	73
Significance Level (P)		0.0858
LSD (P=0.05)		n.s.

TABLE 8: Canada thistle mortality for four application timings when averaged over herbicide treatments. Each value is the mean of 6 observations.

Application Timing	Canada thistle Control
	(%)
Pre-Bud	79
Late Pre-Bud	70
Bud	74
Bloom	82
Significance Level (P)	0.1081
LSD (P=0.05)	n.s.

TOTAL VEGETATION CONTROL STUDIES

Three total vegetation control studies were conducted during the 1991 research season.

1. Comparison of Experimental Formulations for Bareground Weed Control - five experimental herbicide formulations were evaluated for their potential as total vegetation control products.
2. Evaluation of Operational Scale Applications of Bare Ground Treatments - five herbicide combinations were evaluated for weed control and off-site movement in one acre plots on I-80 in Centre County.
3. Evaluation of Herbicides for Bareground Weed Control - six herbicide treatments were evaluted for bareground weed control and off-site movement near University Park, PA.

The products used in 1991 research studies are listed in Table 1.

1. Comparison of Experimental Formulations for Bareground Weed Control

The objective of this study was to evaluate several experimental herbicides for their effectiveness as total vegetation control materials.

MATERIALS AND METHODS
A study evaluating experimental herbicides for their potential use as bareground materials

TABLE 1: Trade name, active ingredients, formulation, and manufacturer of herbicides used for total vegetation control research in 1991.

Trade Name	Active Ingredients	Formulation	Manufacturer
Arsenal	imazapyr	2 S	American Cyanamid Co.
EXP04005B	experimental	4 SC	Rhone-Poulenc Ag. Co.
EXP30848A	experimental	2.66 EW	Rhone-Poulenc Ag. Co.
EXP30849A	experimental	3 EW	Rhone-Poulenc Ag. Co.
Hyvar X	bromacil	80 DF	E.I. du Pont de Nemours & Co.
Karmex	diuron	80 DF	E.I. du Pont de Nemours & Co.
Oust	sulfometuron methyl	75 DF	E.I. du Pont de Nemours & Co.
Ronstar (EXP)	oxadiazon	2 EC	Rhone-Poulenc Ag. Co.
Roundup	glyphosate	4 S	Monsanto Co.
Solicam	norflurazon	80 DF	Sandoz Crop Protection
Spike	tebuthiuron	80 WSP	DowElanco
Surflan	oryzalin	4 AS	DowElanco

was established along a section of unmaintained fenceline at the University Park Airport. The herbicides were applied to mature vegetation and each contained a burn-down component plus a soil residual herbicide. The treatments were applied June 26, 1991, using a hand-held, CO_2-powered sprayer delivering 35 GPA at 30 psi with one Spraying Systems OC-08 spray tip treating a 3 ft swath. The plots were 25 ft long, and arranged in a randomized complete block design with three replications. The products and application rates are listed in Table 2.

A visual rating of percent ground cover was taken on June 26, the day of the application, in order to establish a basis upon which bareground control could be evaluted over the duration of the study. Predominant weed species present at this time included *Rubus* spp., goldenrod (*Solidago* spp.), and quackgrass (*Agropyron repens*). Visual ratings of percent ground cover were taken August 5, and October 21, 40 and 117 DAT, respectively. Rating results are reported in Table 3.

RESULTS

On August 5, 40 DAT, all herbicide treatments were providing significant weed control compared to the check, but there were no differences between the herbicide treatments.. On October 21, 117 DAT, none of the treatments were providing acceptable bareground control, and

percent ground cover ratings for all treatments were at or near the pre-treatment level. The species present at this rating included quackgrass, Rubus, goldenrod, wild carrot (*Daucus carota*), white heath aster (*Aster pilosus*), tall fescue (*Festuca arundinacea*), red sorrel (*Rumex acetosella*), and Canada thistle (*Cirsium arvense*).

TABLE 2: Products and application rates for herbicide treatments applied June 26, 1991 to mature vegetation along a section of fenceline at the University Park Airport.

Treatment	Application Rate (oz product/acre)	Application Rate (lb ai/acre)
1. Untreated Check	- - -	- - -
2. Ronstar + Roundup	128 + 64	2.0 + 2.0
3. Surflan + Roundup	64 + 64	2.0 + 2.0
4. EXP 30848A	192	3.99
5. EXP 30849A	170	3.98
6. EXP 04005B + Roundup	16 + 64	0.5 + 2.0

CONCLUSIONS

The high level o fcontrol at 40 DAT indicates that the herbicides used effectiely controlled the existing vegetatin andd provided some redidual control of annual weeds from seed. The lack of control at 117 DAT showed that the herbicides did not provide long-lasting residual control, or did not provide enough activity to completely control the existing perennial weeds.

2. Evaluation of Operational Scale Applications of Bare Ground Treatments

MATERIALS AND METHODS

Five herbicide combinations were applied to sections of guiderail along I-80 near Bellefonte, PA, for evaluation of off-site herbicide movement. Due to the accumulation of highway anti-skid material this site had a coarse, gravelly surface, creating the potential for runoff of herbicides from the treated areas. Treatments were applied May 13 with a Cibolo Swinglok Model "A" sprayer delivering 40 GPA at 30 psi to a 5 ft swath at 10 mph. Each treatment was applied to 1.0 acre. Products, application rates, and material costs are listed in Table 4.

RESULTS

Visual ratings of percent ground cover were not recorded, due to very low weed pressure, however the plots were evaluated for off-site herbicide movement on July 25 and October 14, 73 and 150 DAT, respectively. At 73 DAT very little vegetation was observed growing in the treated segments along I-80. Spike and Hyvar X were the only treatments that moved off-site significantly. Spike moved the farthest, with surface injury up to 10 ft beyond the edge of the treatment pattern. Injury of boxelder maple from root pick-up was observed up to 20 ft from the treatment area.. Subsequent observations indicated that up to 3.5 ft of the 5 ft treatment swath was actually paved, with a 0.5 to 1.5 in covering of antiskid material. Observations 150 DAT

TABLE 4: Herbicide application rates, and material costs for bare ground treatments applied to guiderails along I-80 on May 13.

Product	Application Rate (product/acre)	Application Rate (lb ai/acre)	Material Cost ($/acre)
1. Arsenal + Karmex	3 pt + 8 lb	0.75 + 6.4	83.27
2. Oust + Karmex	3 oz + 8 lb	0.14 + 6.4	53.55
3. Hyvar X + Karmex	5 lb + 8 lb	4 + 6.4	88.32
4. Spike + Karmex	4 lb + 8 lb	3.2 + 6.4	93.48
5. Solicam + Karmex	4 lb + 4 lb	2.8 + 3.2	72.95

did not reveal additional off-site movement, and regrowth of crownvetch was observed within off-site areas that previously had shown injury.

CONCLUSIONS

Off-site injury observed with Spike and Hyvar X were probably due to application of these materials to the paved shoulder. If the herbicide applied to the paved area moved into the adjacent

unpaved area under the guiderail, this would result in a application rate 3.3 times greater than intended. Despite the drought experienced in 1991, there was probably enough rainfall to move these herbicides from the paved area, and down the slope.

3. Evaluation of Herbicides for Bareground Weed Control

MATERIALS AND METHODS

Six herbicide treatments were applied to a guiderail site along SR 3007 near University Park, PA, for evaluation of weed control and observations of off-site herbicide movement (Table 5). This area was originally scheduled to be sprayed in late May. On May 3, the area behind the guiderail was seeded with annual ryegrass, which was intended to fill in bare areas, and serve as an indicator for herbicide movement. However, due to drought conditions, the ryegrass never established, and the area was not treated until June 27. Due to the accumulation of highway antiskid material this site had a coarse, gravelly surface creating the potential for runoff of herbicides from the treated areas. Treatments were applied to 3 by 50 ft plots using a hand-held, CO_2-pressurized sprayer delivering 35 GPA at 30 psi using one Spraying Systems OC-08 spray tip. The experimental plots were arranged in a randomized complete block design with three

TABLE 5: Herbicide application rates, and per/acre treatment costs for bareground weed control.

Product	Application Rate (product/acre)	Application Rate (lb ai/acre)	Material Cost ($/acre)
1. Arsenal	3 pt	0.75	53.45
2. Oust	3 oz	0.14	23.23
3. Spike	4 lb	3.2	63.16
4. Hyvar X	5 lb	4	55.00
5. Karmex	10 lb	6.4	37.90
6. Solicam + Karmex	4 lb + 4 lb	2.8 + 3.2	72.95
7. Untreated Check	- - -	- - -	- - -

replications. Weed pressure at this site was inconsistent, ranging from 10 to 75 % during the pre-treatment cover rating on June 26. The most common weed species present were common ragweed (*Ambrosia artemisiifolia*), yellow sweetclover (*Melilotus officinalis*), and wild parsnip (*Pastinaca sativa*) Products, application rates, and material costs are listed in Table 5. Visual ratings of percent ground cover were taken July 24 and October 13, 27 and 108 DAT, respectively.

RESULTS

At both rating periods, all treatments were significantly different than the untreated check which was rated at 48 and 43 percent ground cover 27 and 108 DAT, respectively (Table 6). Ratings at 27 and 108 DAT were similar, with the Arsenal, Oust, Spike, Hyvar X, and Karmex treated plots providing acceptable bareground control. The combination of Solicam plus Karmex did not

provide acceptable control. At 27 DAT the only off-site movement observed was in the Spike and Hyvar X plots. Spike moved the farthest, with one narrow 'finger' of injury observed 8 ft beyond the edge of the treatment area. No evidence of off-site injury remained 108 DAT.

TABLE 6: Percent ground cover ratings for guiderail treatments applied June 27, 1991 to sections of guiderail on SR 3007 near University Park, PA. Each cover value is the mean of three replications.

Product	Application Rate	Ground Cover June 26	Ground Cover July 24	Ground Cover October 13
	(product/acre)	(%)	(%)	(%)
1. Arsenal	48	35	9	11
2. Oust	3	33	14	12
3. Spike	64	38	7	9
4. Hyvar X	80	37	14	17
5. Karmex	160	32	8	14
6. Solicam + Karmex	64 + 64	32	22	28
7. Check	—	58	48	43
Significance Level (P)			0.0004	0.0103
LSD (P=0.05)			14	17