Roadside Vegetation Management Research – 2011 Report

ANNUAL REPORT

June 30, 2011

By Jon M. Johnson, Kirsten L. Lloyd, James C. Sellmer, and Arthur E. Gover

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16. Abstract

This report details a cooperative research project performed for the Pennsylvania Department of Transportation's Bureau of Maintenance and Operations by Penn State. The report includes the following: Evaluation of Aminocyclopyrachlor for use in Cut Stump Applications, Preliminary Efficacy of Aminocyclopyrachlor in Combination with Krenite for Brush Control, Japanese Knotweed Control: Comparison of Garlon 3A/Escort Efficacy to Standard Sequential Cutting and Glyphosate Application, Evaluation of Aminocyclopyrachlor for Selective Weed Control in Turf, Evaluation of Aminocyclopyrachlor Tank Mixes Compared to Aminopyralid for Broadleaf Weed Control, Evaluation of Fall-Applied Herbicides for Removal of Poison Hemlock from Crownvetch Groundcover, Bareground Comparison Using Common Tank Mixes, MAT28 in Combination with Preemergence Herbicides For Season-Long Bareground Weed Control, Native Seed Mix Establishment Implementation – Year Three, Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Two, Roadsides for Wildlife, Summary of Observations on an Established Living Snow Fence

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The authors would like to begin by thanking the PennDOT District Roadside Specialists who have been instrumental in locating the field sites needed for this research. Our sincere appreciation goes to Mr. Joe Demko for his support of this research project. We also thank Tracey Harpster, research support technician, for her invaluable assistance and student employee, Ms. Andrea Schwander.

We are grateful for the assistance of the representatives of the various manufacturers providing products for the vegetation management industry, who have lent their time, expertise, and material support on many occasions. The following manufacturers assisted this research project during the 2010 season: E.I. DuPont de Nemours & Co. and Ernst Conservation Seeds.

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INTRODUCTION

In October 1985, personnel at Penn State began a cooperative research project with the Pennsylvania Department of Transportation (PennDOT) 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 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

Report # PA92-4620 + 85-08 - Roadside Vegetation Management Research Report
- Sixth Year Report

Report # PA93-4620 + 85-08 - Roadside Vegetation Management Research Report
- Seventh Year Report

Report # PA94-4620 + 85-08 - Roadside Vegetation Management Research Report
- Eighth Year Report

Report # PA95-4620 + 85-08 - Roadside Vegetation Management Research Report
- Ninth Year Report

Report # PA96-4620 + 85-08 - Roadside Vegetation Management Research Report
- Tenth Year Report

Report # PA97-4620 + 85-08 - Roadside Vegetation Management Research Report
- Eleventh Year Report

Report # PA98-4620 + 85-08 - Roadside Vegetation Management Research Report
- Twelfth Year Report

Report # PA99-4620 + 85-08 - Roadside Vegetation Management Research Report
- Thirteenth Year Report

Report # PA00-4620 + 85-08 - Roadside Vegetation Management Research Report
- Fourteenth Year Report

Report # PA01-4620 + 85-08 - Roadside Vegetation Management Research Report
- Fifteenth Year Report

Report # PA02-4620 + 85-08 - Roadside Vegetation Management Research Report
- Sixteenth Year Report

Report # PA03-4620 + 85-08 - Roadside Vegetation Management Research Report
- Seventeenth Year Report

Report # PA04-4620 + 85-08 - Roadside Vegetation Management Research Report - Eighteenth Year Report

Report # PA05-4620 + 85-08 - Roadside Vegetation Management Research Report - Nineteenth Year Report

Report # PA-2008-003-PSU 005 Roadside Vegetation Management Research Report - Twenty-second Year Report

Report # PA-4620-08-01 / LTI 2009-23 Roadside Vegetation Management Research Report - Twenty-third Year Report

Report # PA-2010-005-PSU-016 Roadside Vegetation Management Research Report - Twenty-fourth Year Report

These reports are available by request from the authors, and are available online in portable document format (PDF) at http://vm.cas.psu.edu.

Use of Statistics in This Report

Many of the individual reports in this document make use of statistics, particularly techniques involved in the analysis of variance. The use of these techniques allows for the establishment of criteria for significance, or, when the differences between numbers are most likely due to the different treatments, rather than due to chance. We have relied almost exclusively on the commonly used probability level of 0.05. When a treatment effect is significant at the 0.05 level, this indicates that there is only a five percent chance that the differences are due to chance alone. At the bottom of the results tables where analysis of variance has been employed, there is a value for least significant difference (LSD). When analysis of variance indicates that the probability that the variation in the data is due to chance is equal or less than 0.05, Fisher's LSD means separation test is used. When the difference between two treatment means is equal or greater than the LSD value, these two values are significantly different. When the probability that the variation in the data is due to chance is greater than 0.05, the LSD value is reported as "n.s.," indicating non-significant.

This report includes information from studies relating to roadside brush control, herbaceous weed control, total vegetation control, native species establishment and roadside vegetation management demonstrations. Herbicides are referred to as product names for ease of reading. The herbicides used are listed on the following page by product name, active ingredients, formulation, and manufacturer.

Product Information Referenced in This Report

The following details additional information for products referred to in this report. EC=emulsifiable concentrate, F = flowable liquid, ME=microencapsulated, OL=oil soluble, S=water soluble, SP=soluble poweder, WDG=water-dispersible granules, WP = wettable powder.

Trade Name	Active Ingredients	Formulation	Manufacturer
Aquaneat	glyphosate	4 S	Nufarm Turf & Specialty
Arsenal	imazapyr	2 S	BASF Specialty Products
Authority	sulfentrazone	75 WDG	E.I. DuPont de Nemours & Co.
Basagran T/O	bentazon	4 S	BASF Specialty Products
Clearcast	imazamox	1 S	BASF Specialty Products
Escort XP	metsulfuron methyl	60 WDG	E.I. DuPont de Nemours & Co.
Garlon 3A	triclopyr amine	3 S	Dow AgroSciences LLC
Garlon 4	triclopyr ester	4 EC	Dow AgroSciences LLC
Glyflo	glyphosate	3 S	Micro Flo Company
GlyPro	glyphosate	4 S	Dow AgroSciences LLC
Goal 2XL	oxyfluorfen	2 EC	Dow AgroSciences LLC
Karmex XP	diuron	80 WDG	E.I. DuPont de Nemours & Co.
KJM44	aminocyclopyrachlor	2 F	E.I. DuPont de Nemours & Co.
Krenite S	fosamine	4 S	E.I. DuPont de Nemours & Co.
Krovar I	bromacil + diuron	40 + 40 WDG	E.I. DuPont de Nemours & Co.
MAT28	aminocyclopyrachlor	1 OL	E.I. DuPont de Nemours & Co.
MAT28	aminocyclopyrachlor	50 WDG	E.I. DuPont de Nemours & Co.
Matrix	rimsulfuron	25 WDG	E.I. DuPont de Nemours & Co.
Milestone VM	aminopyralid	2 S	Dow AgroSciences LLC
Oust Extra	sulfometuron + metsulfuron	56.25 + 15 WDG	E.I DuPont de Nemours & Co.
Overdrive	dicamba + diflufenzopyr	70 WDG	BASF Specialty Products
Payload	flumioxazin	51 WDG	Valent U.S.A. Corporation
Pendulum AQ	pendimethalin	3.8 ME	BASF Specialty Products
Plateau	imazapic	2 S	BASF Specialty Products
Proclipse	prodiamine	65 WDG	Nufarm Speciality Products
Prowl	pendimethalin	3.3 EC	BASF Specialty Products
RoundUp	glyphosate	3 S	Monsanto Company
RoundUp PRO Dry	glyphosate	65 SP	Monsanto Company
Simazine	simazine	4F	Drexel Chemical Co.
Stalker	imazapyr	2 EC	BASF Specialty Products
Surflan AS	oryzalin	4 F	United Phosphorus, Inc.
Telar XP	chlorsulfuron	75 WDG	E.I. DuPont de Nemours & Co.
Throttle XP	chlorsulfuron, sulfometuron, + sulfentrazone	9 + 18 + 48 WDG	E.I. DuPont de Nemours & Co.
Valor	flumioxazin	51 WDG	Valent U.S.A. Corporation

EVALUATION OF AMINOCYCLOPYRACHLOR FOR USE IN CUT STUMP APPLICATIONS

<u>Herbicide trade and common chemical names:</u> Garlon 4 (*triclopyr* ester), KJM44 (2 lb *aminocyclopyrachlor*/gal), MAT28 (1 lb *aminocyclopyrachlor*/gal, oil-soluble formulation), Stalker (*imazapyr*).

<u>Plant common and scientific names:</u> bigtooth aspen (*Populus grandidentata*), black locust (*Robinia pseudoacacia*), green ash (*Fraxinus pennsylvanica*), pin cherry (*Prunus pensylvanica* L. *f*.), scrub oak (*Quercus ilicifolia*), sugar maple (*Acer saccharum*).

ABSTRACT

During mechanical tree and brush removal operations, cut surfaces are routinely treated with herbicides to prevent resprouting. This trial investigated the efficacy of an experimental formulation of the new active ingredient *aminocyclopyrachlor* designed for oil-based applications. Through 375 days after treatment, the oil-solutble 1 lb *aminocyclopyrachlor*/gal formulation suppressed stump sprouts of black locust, sugar maple, and scrub oak at rates as low as 5% v/v when mixed with basal oil. Untreated stumps of all species produced sprouts.

INTRODUCTION

Tree and brush removal operations occur throughout the year. In order to prevent resprouting, herbicides are routinely applied to the remaining cut surfaces. Garlon 4 (*triclopyr*) alone, or combined with Stalker, has been the primary herbicide used for stump applications and is mixed in basal oil to enhance penetration into bark or through callus tissue. Another common option is Pathfinder II, a ready-to-use blend of *triclopyr* and basal oil. Work conducted in 2008 using KJM44 (2 lb *aminocyclopyrachlor*/gal) for cut surface treatments on green ash, pin cherry, and bigtooth aspen showed promising results; however, the formulation was not miscible in basal oil at higher concentrations of 10 to 15 percent v/v[1]. In this trial, an experimental formulation that contains 1 lb *aminocyclopyrachlor*/gal and was designed to mix readily with oil was evaluated for cut stump treatment of black locust, sugar maple, and scrub oak.

MATERIALS AND METHODS

Treatments were applied to cut stems of three tree species, black locust, scrub oak, and sugar maple. The trial was a completely randomized design with ten stems per treatment. Stem diameter ranges (in inches) for the species (max, min, mean) were as follows, black locust 6.5, 1.1, 2.6; scrub oak 6.3, 0.9, 2.3; and sugar maple 3.0, 0.7, 1.6. Black locust and sugar maple stands were located on SR1008 east of Bellwood, PA. Scrub oak was located on I-99 in State College, PA. All stems were treated immediately after cutting on June 2, 3, and 4, 2010 for maple, locust, and oak, respectively. Treatments were applied to the entire cut surface for trees with diameters less than 3 in, and larger trees were treated only on the outer 2 to 3 in of the

[1] Johnson, J.M. et al 2010. Response of Woody Species to Cut Surface Applications of Aminocyclopyrachlor. Roadside Vegetation Management Research Report - Twenty-fourth Year Report, pp. 6-7.

stump; the application covered exposed bark from the root collar to the soil line. Treatments were applied using a CO_2-powered backpack sprayer equipped with a Gunjet spray gun and Y-2 tip. The eight treatments included MAT28 (1 lb *aminocyclopyrachlor*/gal) alone at 5, 10, and 20% v/v; MAT 28 at 5% plus Garlon 4 at 10% v/v; MAT28 at 10% plus Stalker at 1% v/v; Garlon 4 alone at 30% v/v; Garlon 4 at 20% plus Stalker at 1% v/v; and an untreated check. All treatments were mixed in Arborchem Low Odor Basal Oil[2].

Targets were evaluated for resprouts on July 2, August 31, and November 3, 2010 and on June 15, 2011, approximately 30, 90, 150, and 375, days after treatment, DAT, respectively. The number of sprouts and caliper of each sprout at its site of attachment was recorded for each target.

RESULTS AND DISCUSSION

Over one year after treatment, only untreated stumps had sprouted. At 150 DAT, black locust had 100 percent of the untreated stumps sprout averaging 10 sprouts per stump at 0.21 in caliper. Scrub oak had 100 percent of the untreated stumps sprout, averaging 7 sprouts per stump at 0.20 in caliper. For sugar maple, 80 percent of untreated stumps sprouted, averaging 5 sprouts per stump at 0.15 in caliper. The percentage of untreated stumps that had sprouted remained the same at 375 DAT. Therefore, all treatments provided 100 percent long-term control, as we do not expect future flushes of growth from the stumps.

CONCLUSIONS

The new oil-soluble formulation of *aminocyclopyrachlor* was evaluated for its utility in cut-surface applications in comparison with the current industry standard, Garlon 4. All herbicide treatments provided complete control of unwanted stump sprouts from black locust, scrub oak, and sugar maple at over one year after application, at rates of MAT28 (oil-soluble, 1 lb *aminocyclopyrachlor*/gal formulation) as low as 5% v/v alone.

MANAGEMENT IMPLICATIONS

Aminocyclopyrachlor premixes (e.g., Streamline™ and Perspective™) are commercially-available as water-dispersible granules but are not labeled for cut surface treatment. The 1 lb/gal oil-soluble formulation used in this trial is not among the combinations available but may add another viable option for cut stump herbicide applications in the future.

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[2] Arborchem Low Odor Basal Oil (Arborchem Products, Mechanicsburg, PA).

PRELIMINARY EFFICACY OF AMINOCYCLOPYRACHLOR IN COMBINATION WITH KRENITE FOR BRUSH CONTROL

Herbicide trade and common chemical names: Arsenal (*imazapyr*), Escort XP (*metsulfuron*), Krenite (*fosamine*), MAT28 50SG (*aminocyclopyrachlor*), Roundup (*glyphosate).*

Plant common and scientific names: Bigtooth aspen (*Populus grandidentata*), black birch (*Betula lenta*), black cherry (*Prunus serotina*), blackberry (*Rubus* spp.), red oak (*Quercus rubra*), red maple (*Acer rubrum*), sweet fern (*Comptonia peregrina*), trembling aspen (*Populus tremuloides*)

ABSTRACT

Brush control is an integral component of PennDOT's roadside vegetation management program. DuPont is currently developing Streamline™, a premix of the new synthetic auxin MAT28 and Escort XP. To evaluate this premix alone and in combination with Krenite, Roundup, Krenite plus Arsenal, or Roundup plus Arsenal, a reasonable facsimile was prepared to simulate the proposed DuPont product. The Streamline™ simulated product was achieved by mixing *aminocyclopyrachlor* and *metsulfuron* at 39.5 percent and 12.6 percent by weight, respectively. Simulated Streamline™ at 9.5 oz/ac alone or in combination with either Krenite at 64 to 128 oz/ac or Roundup at 128 oz/ac caused acceptable to excellent initial injury to red maple, aspen, and black cherry. The addition of Arsenal did not increase symptoms. Black birch was slow to react to all treatments, with only minor initial injury. After approximately one year, all simulated Streamline treatments provided excellent control of red maple, aspen, black cherry, and blackberry. Among the combinations of simulated Streamline with Krenite, Roundup, and Arsenal, the best control of black birch one year after treatment was Krenite at 96 oz/ac plus simulated Streamline; Krenite at 128 oz/ac with Arsenal at 4 oz/ac plus simulated Streamline; and Roundup at 128 oz/ac plus simulated Streamline with greater than 85 percent control. The variability in black birch control suggests that Krenite or Arsenal may have antagonistic effects when combined with Streamline. Overall, simulated Streamline appears to have a robust potential for deciduous brush control, but future evaluations using the officially released version of Streamline™ are recommended to assure the final formulation interacts similarly to the results reported here. Additional trials conducted at the level of individual stems (i.e., to assure uniformity in plant size and health) rather than by plot will help determine whether other herbicides act antagonistically to Streamline.

INTRODUCTION

Woody plant species continually invade open areas in the process of natural succession, which, without human intervention, would result in a forested landscape throughout most of Pennsylvania. Therefore, brush control is an integral component of roadside vegetation management. PennDOT's selective, or weed and brush, herbicide program targets brush and broadleaf weed growth in the safety clear zone, which extends approximately 30 ft from the edge of the roadway, depending on the width of the right-of-way. Garlon 3A at 64 oz/ac is commonly tank mixed with Escort XP at 0.5 oz/ac for use in the selective program. Another herbicide program, sidetrimming, relies on the herbicide Krenite to suppress brush that encroaches onto the roadway in areas with a limited right-of-way.

Krenite is a unique herbicide that is labeled for control and/or suppression of woody species. It is not systemic; therefore, only limbs contacted by spray are affected. Krenite can be applied through the onset of fall color and prevents growth and production of foliage the following spring in susceptible species[1]. Notably, box elder, black cherry, sassafras, and aspen are less susceptible to Krenite[2]. Where resistant species are common, Krenite is commonly tank mixed with Arsenal to increase its spectrum of control.

Aminocyclopyrachlor, a new synthetic auxin in development by DuPont, has provided excellent results for control of black locust, tulip poplar, and red oak in previous work when applied to foliage at carrier rates of 50 to 100 gal/ac[3]. This herbicide, given the experimental name MAT28, is expected to be available in several premixes, including Streamline™, which is composed of *aminocyclopyrachlor* and *metsulfuron* at 39.5 percent and 12.6 percent by weight, respectively[4].

The efficacy of simulated Streamline™ alone and combined with either Krenite, Krenite plus Arsenal, Roundup, or Roundup plus Arsenal for general brush control was investigated.

MATERIALS AND METHODS

Mixed brush species were targeted on the I-99 right-of-way in Rush Township, Centre County, near Port Matilda, PA. Herbicide treatments included MAT28 at 7.5 oz/ac plus Escort XP at 2 oz/ac alone (i.e., representative of Streamline at 9.5 oz/ac) and combined with either Krenite at 64, 96, or 128 oz/ac alone and with Arsenal added at 4.0 oz/ac; or with Roundup (4 lb *glyphosate* ae/gal) at 128 oz/ac alone and with Arsenal at 4.0 oz/ac. Additional treatments were Krenite alone at 192 oz/ac, Roundup alone at 192 oz/ac, and an untreated check. All applications included nonionic surfactant at 1.00 percent v/v. Plots 25 by 15 ft in size were established in a randomized complete block design with three replications. Treatments were applied at 25 gal/ac on June 8, 2010, using a CO_2-powered backpack sprayer equipped with a GunJet spray gun and an X-6 tip.

Percent injury (0 = no injury, 100 = necrosis) to red maple, bigtooth and trembling aspen, black birch, black cherry, and blackberry was evaluated on July 12, 2010, 34 days after treatment, DAT. Percent control (0=no control, 100=plant death) was rated on June 10, 2011, 367 DAT. Four data points (i.e., control values ranging from 5 to 25 percent) for red maple were excluded from analysis because it appeared that healthy, smaller plants (i.e., one to two feet in height) in the understory had been shielded from spray coverage and therefore did not represent the efficacy of the herbicide treatment. All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Fisher's Protected LSD.

[1] E. I. Du Pont de Nemours and Company. 2010. Krenite S Herbicide Label. Pub SL – 1532, 8 pp.
[2] PennDOT. 2010. Pub 23 Maintenance Manual: Chaper 13- Roadside Management, p. 13.
[3] Johnson, J.M. et al. 2009. Response of Black Locust, Red Oak, and Tulip Poplar to Foliar Applications of DPX-KJM44. Roadside Vegetation Management Annual Report – Twenty-third Year Report, pp. 11-13.
[4] E. I. du Pont de Nemours and Company. 2009. Streamline Draft Label. Pub D – 1386, 12 pp.

RESULTS AND DISCUSSION

At 34 DAT, all simulated Streamline™ treatments caused robust initial injury to red maple (72 to 100 percent), aspen (98 to 100 percent), and black cherry (92 to 100 percent), with no significant differences among simulated Streamline™ alone or simulated Streamline™ plus Krenite or Roundup (Table 1). However, the maximum injury to black birch by any treatment was only 18 percent. There were no significant differences in injury among the three rates of Krenite tested; however, Krenite is expected to improve long-term control (i.e., in the following season) rather than to increase short-term injury of deciduous species[5]. The addition of Arsenal did not significantly increase injury to any of the four species evaluated.

At approximately one year after application, all treatments except Krenite alone provided excellent control (i.e., greater than 85 percent) of red maple, aspen, black cherry, and blackberry (Table 2). Despite initially low injury levels to birch, the effects of several simulated Streamline mixes increased over time and were significantly greater than those produced by either Roundup, Krenite, or simulated Streamline alone. Krenite at 96 oz/ac plus simulated Streamline; Krenite at 128 oz/ac with Arsenal at 4 oz/ac plus simulated Streamline; and Roundup at 128 oz/ac plus simulated Streamline produced year-long control ratings of greater than 85 percent. Not all combinations with simulated Streamline were as effective. Control values for the simulated Streamline mixes decreased significantly as the rate of Krenite was increased from 96 to 128 oz/ac; however, the addition of Arsenal at 4 oz/ac negated this effect. Alternatively, when Arsenal was added to the simulated Streamline plus Roundup mix, control decreased from 87 to 55 percent, though not significantly. At this point, it is unclear whether the combination of these products with Streamline has the potential to produce antagonistic effects. However, it is apparent that birch was slower to respond to the herbicide treatments than the other species.

CONCLUSIONS

Streamline™ at 9.5 oz/ac, simulated by mixing MAT28 at 7.5 plus Escort XP at 2 oz/ac, alone or in combination with either Krenite at 64 to 128 oz/ac or Roundup at 128 oz/ac caused acceptable to excellent initial injury to red maple, aspen, and black cherry. The addition of Arsenal did not increase symptoms. Black birch was slow to react to all treatments, with only minor initial injury. After approximately one year, all simulated Streamline treatments provided excellent control of red maple, aspen, black cherry, and blackberry.

Among the combinations of simulated Streamline with Krenite, Roundup, and Arsenal, the best control of black birch one year after treatment was Krenite at 96 oz/ac plus simulated Streamline; Krenite at 128 oz/ac with Arsenal at 4 oz/ac plus simulated Streamline; and Roundup at 128 oz/ac plus simulated Streamline with greater than 85 percent control.

The variability in black birch control suggests that Krenite or Arsenal may have antagonistic effects when combined with Streamline. Future trials conducted at the level of individual stems (i.e., to assure uniformity in plant size and health) rather than by plot should help determine whether herbicides act antagonistically to Streamline.

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[5] E. I. Du Pont de Nemours and Company. 2010. Krenite S Herbicide Label. Pub SL – 1532, 8 pp.

MANAGEMENT IMPLICATIONS

Simulated Streamline appears to have a robust potential for deciduous brush control; however, further research is needed to determine the utility and appropriate rates of tank mix partners. Future evaluations using the officially released version of Streamline™ are recommended to assure the final formulation interacts similarly to the results reported here.

Table 1. Visual estimates of injury (0 = no injury, 100 = necrosis) to red maple (*Acer rubrum*), trembling and bigtooth aspen (*Populus spp.*), black birch (*Betula lenta*), black cherry (*Prunus serotina*), and blackberry (*Rubus spp.*) as evaluated on July 12, 2010, 34 days after treatment. Treatments were applied at 25 gal/ac to 25 by 15 ft plots on June 8, 2010, in Port Matilda, PA. All applications included nonionic surfactant at 1.00 % v/v. Each value is the mean of three replications. Differences between means were considered statistically significant at $p \leq 0.05$. ns = not significant.

Product	Rate	Red maple	*Populus* spp.	Black birch	Black cherry	*Rubus* spp.
	oz/ac	---	---	% injury	---	---
MAT28 Escort	7.5 2	78	100	8	92	50
Krenite*	64	95	99	12	100	77
Krenite*	96	94	99	15	100	85
Krenite*	128	99	100	10	100	85
Krenite* Arsenal	64 4	99	100	15	100	72
Krenite* Arsenal	96 4	97	99	13	98	73
Krenite* Arsenal	128 4	80	100	17	100	63
Roundup*	128	72	98	18	96	63
Roundup* Arsenal	128 4	83	99	17	99	72
Krenite	192	5	25	10	10	15
Roundup	192	43	99	10	67	28
untreated	---	0	0	0	0	0
LSD ($p<0.5$)		33	11	ns	15	31

*in combination with MAT28 at 7.5 plus Escort at 2 oz/ac, which is equivalent to Streamline™ at 9.5 oz/ac.

Table 2. Visual estimates of control (0=no control, 100=plant death) to red maple (*Acer rubrum*), trembling and bigtooth aspen (*Populus spp.*), black birch (*Betula lenta*), black cherry (*Prunus serotina*), and blackberry (*Rubus spp.*) as evaluated on June 10, 2011, approximately 367 DAT. Treatments were applied at 25 gal/ac to 25 by 15 ft plots on June 8, 2010, in Port Matilda, PA. All applications included nonionic surfactant at 1.00 % v/v. Each value is the mean of three replications. Differences between means were considered statistically significant at $p \leq 0.05$. Values followed by the same letter are not significantly different.

Product	Rate	Red maple	*Populus* spp.	Black birch	Black cherry	*Rubus* spp.
	oz/ac	% control				
MAT28	7.5	94 ab	100 a	50 c	92 a	97 a
Escort	2					
Krenite*	64	99 a	100 a	74 abc	100 a	100 a
Krenite*	96	99 a	99 a	94 a	100 a	100 a
Krenite*	128	95 a	100 a	40 c	100 a	100 a
Krenite*	64	98 a	100 a	53 bc	100 a	100 a
Arsenal	4					
Krenite*	96	98 a	99 a	67 abc	100 a	100 a
Arsenal	4					
Krenite*	128	99 a	100 a	91 ab	100 a	100 a
Arsenal	4					
Roundup*	128	94 ab	100 a	87 ab	98 a	99 a
Roundup*	128	99 a	100 a	55 bc	100 a	100 a
Arsenal	4					
Krenite	192	8 c	45 b	40 c	35 b	60 b
Roundup	192	85 b	99 a	47 c	99 a	97 a
untreated	---	0 d	0 c	0 d	0 c	0 c

*in combination with MAT28 at 7.5 plus Escort at 2 oz/ac, which is equivalent to Streamline™ at 9.5 oz/ac.

JAPANESE KNOTWEED CONTROL: COMPARISON OF GARLON 3A/ESCORT EFFICACY TO STANDARD SEQUENTIAL CUTTING AND GLYPHOSATE APPLICATION

Herbicde trade and common chemical names: Aquaneat (*glyphosate*), Escort XP (*metsulfuron*), Garlon 3A (*triclopyr*)

Plant common and scientific names: Japanese knotweed (*Polygonum cuspidatum* = *Fallopia japonica*)

ABSTRACT

Japanese knotweed is an aggressive perennial plant that requires multiple-step control and maintenance phases. The objective of this trial was to evaluate the efficacy of chemical mowing with Garlon 3A at 64 oz/ac plus Escort at 1 oz/ac, a standard mix for selective weed and brush control, relative to several *glyphosate*-based treatments. Among the two-step knotweed control methods evaluated, chemical treatments significantly outperformed cutting alone. Although the *glyphosate* treatments, including cut-then-spray, chemical mowing, and high-volume strategies, tended to provide slightly better results, chemical mowing with Garlon 3A at 64 oz/ac plus Escort at 1 oz/ac provided good control, reducing knotweed ground cover by 87 percent relative to the untreated check at the end of the season after treatment. In a multiple-operation knotweed control program, chemical mowing with the standard selective weed and brush mix of Garlon 3A plus Escort, followed by late-season treatment with Aquaneat at 96 oz/ac, provides a useful tool for roadside managers to treat sporadic knotweed patches.

INTRODUCTION

Japanese knotweed is a rhizomatous, herbaceous perennial that grows in tall, dense stands that impede motorist sight distance and access to roadside areas. Control of knotweed requires a multiple-step control phase followed by continued maintenance[1]. Previous trials have demonstrated the utility of the non-selective herbicide *glyphosate* applied to intact knotweed late in the growing season[2], to well-developed knotweed regrowth following either a June cutting[3] or after a mid-summer "chemical" mowing[4] (i.e., injury induced via herbicide application). In addition to *glyphosate*, *triclopyr* has proven effective, at a rate of 128 oz Garlon 3A/ac, as a follow-up to treatment to glyphosate, specifically when the preservation of desirable grasses is a concern[4]. Garlon 3A is a selective herbicide that is generally combined with other herbicides during roadside spray operations. For example, the tank mix of Garlon 3A at 64 oz/ac plus Escort at 1 oz/ac is a standard for selective weed and brush control.

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[1] Gover, A.E. et al. 2005. Managing Japanese Knotweed and Giant Knotweed on Roadsides. Roadside Vegetation Management Factsheet 5. 4 pp. (http://vm.cas.psu.edu/Publications/FS_5_POLCU.pdf)

[2] Gover, A.E. et al. 2005. Control of Japanese Knotweed with Late-season Foliar Herbicide Applications. Roadside Vegetation Management Research Report – Nineteenth Year Report, pp. 20-22.

[3] Johnson, J.M. et al. 2007. Evaluation of Herbicides for Control of Japanese Knotweed. Proceedings of the Northeast Weed Science Society. 61: 74-75. (http://www.newss.org/proceedings/proceedings_2007.pdf)

[4] Johnson, J.M. et al. 2010. Japanese Knotweed Controlled with Glyphosate or Triclopyr Applied Sequentially or Following Cutting. Roadside Vegetation Management Research Report – Twenty-fourth Year Report, pp. 15-18.

The objective of this trial was to evaluate the efficacy of several two operation-treatments utilizing *glyphosate* and *triclopyr*, including the combination of Garlon 3A plus Escort for chemical mowing.

MATERIALS AND METHODS

The trial was established on the shoulder of Fox Hollow Road in State College, PA. Six treatments included cutting twice; cutting followed by Aquaneat at 96 oz/ac; "chemical mowing" with either Aquaneat at 96 oz /ac or Garlon 3A at 64 oz/ac plus Escort at 1 oz/ac, followed by Aquaneat at 96 oz /ac; a "high-volume" treatment with Aquaneat at 96 oz /ac, followed by treatment of resprouts using Aquaneat at 96 oz /ac. The treatments were applied in 2009 to 12 by 15 ft plots in a randomized complete block design with three replications. The twice-cut plots were cut to the ground May 13 and July 7; the cut-then-spray plots were cut to the ground June 16 and sprayed September 3 at 100 gal/ac; the chemically-mowed plots were treated May 13 and September 3 at 100 gal/ac; the high-volume treatment was applied July 3 at 125 gal/ac, and resprouts were treated on September 3 at 200 gal/ac. Each application included nonionic surfactant at 0.25% v/v. The herbicide treatments were applied with a CO_2-powered backpack sprayer equipped with a TeeJet #5500 Adjustable ConeJet nozzle with an X-18 tip for the high-volume applications and an X-12 tip for all other treatments.

The study was visually rated for knotweed cover on May 13, 2009 and May 27 and August 24, 2010. Canopy reduction was evaluated on October 9, 2009. All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Fisher's Protected LSD.

RESULTS AND DISCUSSION

Before plots were cut or chemically mowed on May 13, 2009, knotweed ground cover ranged from 28 to 38 percent, with no significant differences among treatments (Table 1). On October 9, 2009, which corresponds to 94 and 36 days after the second cutting and herbicide applications, respectively, knotweed canopy reduction ranged from 18 to 90 percent among treatments. Chemical mowing with Aquaneat at 96 oz/ac produced a significantly higher canopy reduction (90 percent) than all other treatments (18 to 52 percent), which were not significantly different from one another. The lowest reduction was observed on the twice cut plots, which were statistically similar to the untreated check; however, the difference would likely have been significant if the plots were evaluated closer to the second cutting in early July rather than at end-of-season. On May 27, 2010, knotweed ground cover was 70 percent on the untreated check, 53 percent on twice-cut plots, and ranged from 0 to 2 percent for the remaining treatments, which were all significantly lower than the twice-cut treatment. Knotweed height averaged approximately 8, 6, and 2 ft among the untreated, twice-cut, and chemical treatments, respectively. By August 24, 2010, knotweed accounted for 97 and 100 percent cover on the untreated and twice-cut plots, respectively. All chemical treatments provided relatively similar results at the end of the second season, though the high-volume Aquaneat treatment (3 percent) showed significantly lower cover than chemical mowing with Garlon 3A plus Escort (13 percent). Knotweed height was approximately 9, 6, 3, and 2 ft for the untreated, twice-cut, Garlon 3A plus Escort, and Aquaneat treatments, respectively.

The chemical treatments provided excellent knotweed control. However, knotweed along Fox Hollow road was lower in height and presumably less aggressive than populations that have been observed in other parts of the state[5]. Since the area along Fox Hollow road has been historically managed, knotweed was mowed and likely chemically-treated in the past; although, no inadvertent treatments were made after the study was initiated in May 2009.

CONCLUSIONS

Among the two-step knotweed control methods evaluated, the *glyphosate* treatments, including cut-then-spray, chemical mowing, and high-volume, tended to provide the best results. Chemical mowing with Garlon 3A at 64 oz/ac plus Escort at 1 oz/ac provided good control, reducing knotweed ground cover by 87 percent relative to the untreated check at the end of the season after treatment. The mix of Garlon 3A plus Escort is a viable option for treatment during chemical mowing, during the establishment of desirable grasses, and when treating resprouts that occur after initial glyphosate applications to control knotweed.

MANAGEMENT IMPLICATIONS

As part of a multiple-operation knotweed control program, chemical mowing with the standard selective weed and brush mix of Garlon 3A at 64 oz/ac plus Escort at 1 oz/ac followed by late-season treatment with Aquaneat at 96 oz/ac provides a useful tool for roadside managers to treat knotweed patches and resprouts. However, at a cost of $36.06 per acre, the Garlon/Escort mix is over three times more expensive than treatment with Aquaneat alone (96 oz/ac) at a cost of $10.56 per acre[6]. Therefore, to maximize cost-effectiveness when there is no desirable vegetation present, use multiple *glyphosate* applications.

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[5] Johnson, J.M. et al. 2010. Japanese Knotweed Controlled with Glyphosate or Triclopyr Applied Sequentially or Following Cutting. Roadside Vegetation Management Research Report – Twenty-fourth Year Report, pp. 15-18.
[6] Herbicide costs derived from 2010 PA State Herbicide Contract.

Table 1. Visual estimates of Japanese knotweed ground cover and canopy reduction. Two-step treatments were conducted from May to September 2009 at a roadside site in State College, PA. The twice-cut plots were cut to the ground May 13 and July 7; the cut-then-spray plots were cut to the ground June 16 and sprayed September 3 at 100 gal/ac; the chemically-mowed plots were treated May 13 and September 3 at 100 gal/ac; the high-volume treatment was applied July 3 at 125 gal/ac and resprouts were treated on September 3 at 200 gal/ac. All applications included nonionic surfactant at 0.25% v/v. Each value is the mean of three replications. Differences between means were considered statistically significant at $p \leq 0.05$. ns = not significant.

Treatment	Step 1	Product Rate	Step 2	Product Rate	5/13/09 Ground cover	10/9/09 Canopy Reduction	5/27/10 Ground cover	8/24/10 Ground cover
		oz/ac		oz/ac	---------------- %			-----------------
Untreated	---	---	---	---	28	0	70	97
Cut twice	Cut	---	Cut	---	37	18	53	100
Cut then spray	Cut	---	Aquaneat	96	35	47	1	5
Chemical mow I	Aquaneat	96	Aquaneat	96	33	90	0	7
Chemical mow II	Garlon 3A Escort XP	64 1	Aquaneat	96	38	52	2	13
High volume	Aquaneat	96	Aquaneat	96	30	47	1	3
Protected LSD ($p \leq 0.05$)					ns	35	30	8

EVALUATION OF AMINOCYCLOPYRACHLOR FOR SELECTIVE WEED CONTROL IN TURF

Herbicide trade and common chemical names: Escort XP (*metsulfuron*), MAT28 50SG (*aminocyclopyrachlor*), Matrix (*rimsulfuron*), Milestone VM (*aminopyralid*), Plateau (*imazapic*), Telar XP (*chlorsulfuron*).

Plant common and scientific names: aster (*Aster* spp.), chicory (*Cichorium intybus*), fine fescues (*Festuca spp.*), goldenrod (*Solidago* spp.), tall fescue (*Festuca arundinacea*).

ABSTRACT

The control of broadleaf weeds in roadside turf areas is necessary to provide safety, improve aesthetics, and help maintain the integrity of the turf stand. MAT28, a new synthetic auxin, was evaluated in combination with either Telar XP, Escort XP, or Matrix for dicot weed control and safety to turf after both spring and fall applications. Tested rates of MAT28 plus Telar XP or Escort XP appeared safe on the turf with no significant signs of turf discoloration, whereas the MAT28 plus Matrix combination resulted in obvious turf injury. The combinations and rates used for the spring timing offered excellent control of chicory and goldenrod. Percent injury was high for chicory with fall-applied treatments and marginal for goldenrod and aster. Further evaluation of these two species is needed to determine long-term control.

INTRODUCTION

Broadleaf weed control is a critical component of a roadside vegetation management program. A recent programmed reduction in mowing cycles has demonstrated the importance of broadleaf weed control to assure roadside safety, improve aesthetics, and prevent degradation of the turf stand. Several herbicide tank mixes are presently recommended for this application based on their turf safety and broad-spectrum dicot weed control. Reliance on existing chemistry has the potential to select for herbicide resistant biotypes of the targeted weed species and to increase the abundance of weedy species outside of the control spectrum.

MAT28 (*aminocyclopyrachlor*) is a new synthetic auxin in development by DuPont for release as a premixed combination product with Telar XP or Escort XP for broadleaf weed control applications. MAT28 is selective to grasses and offers both foliar and residual activity. The half-life of MAT28 in turf settings has been observed to range from 37 to 103 days[1]. Therefore, MAT28 offers the potential to provide persistent control of existing and germinating weeds. Unfortunately, MAT28 appears weak against plants within the mustard family[2]. However, tank mixes can be utilized to widen its spectrum of control.

This study was initiated to evaluate broadleaf weed control and turf phytotoxicity of MAT28 tank mixed with either Telar XP, Escort XP, or Matrix for use in for roadside, industrial turf settings.

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[1] E.I. DuPont de Nemours and Company. 2009. DPX-MAT Herbicide Technical Bulletin. https://lists.uaf.edu:8025/pipermail/cnipm-l/attachments/20090310/f10dfb94/MAT28TechBulletin-0001.pdf

[2] Westra, Philip, et al. 2008. Aminocyclopyrachlor for Invasive Weed Management and Restoration Grass Safety in the Central Great Plains. North Central Weed Science Society Proc. 63:203.

MATERIALS AND METHODS

The trial site was located in the median of I-99, north of Tyrone, PA. Plots were 6 by 25 feet in size and were arranged in a randomized complete block design with three replications. Spring-applied treatments included MAT28 at 1.88 plus Telar XP at 0.50 oz/ac, MAT28 at 3.76 plus Telar XP at 1.00 oz/ac; MAT28 at 1.88 plus Escort XP at 0.25 oz/ac; Milestone at 5.00 plus Plateau at 4.00 oz/ac; MAT28 at 1.88 plus Matrix at 2.00 oz/ac; MAT28 at 3.00 plus Matrix at 3.00 oz/ac; and MAT28 at 3.76 plus Telar XP at 0.50 oz/ac. Fall-applied treatments were MAT28 at 3.76 plus Telar XP at 1.00 oz/ac; MAT28 at 3.76 plus Escort XP at 0.50 oz/ac; Milestone at 7.44 plus Escort XP at 0.47 oz/ac; and MAT28 at 3.76 plus Matrix at 4.00 oz/ac. An untreated check was also included in the treatments. CWC Surfactant 90 at 0.25% v/v was added to all treatments. Spring and fall treatments were applied on May 28 and August 25, 2010, respectively, at 40 gal/ac using a CO_2-powered backpack sprayer with 6 ft boom and four Teejet 8004VS even flat fan spray tips.

The study was visually rated for percent total, chicory, goldenrod, tall fescue, and fine fescue cover on May 28, 2010 and August 25, 2010, at time of spring and fall treatment, respectively. For the spring treatments, percent injury (0 = no injury; 50 = epinasty, some chlorosis, minor leaf loss; 90 = significant loss of foliage, severe epinasty, necrosis; and 100 = dead) for chicory and goldenrod and percent phytotoxicity to tall and fine fescues were rated on June 28 (31 days after treatment, DAT) and July 27 (60 DAT). Percent chicory and goldenrod groundcover and percent phytoxicity to tall and fine fescues were evaluated September 10, 2010 (105 DAT). For the fall treatments, percent injury to chicory, goldenrod, and aster and percent phytotoxicity to tall fescue and fine fescue were rated on September 10 (16 days treatment, DAT). Percent injury to chicory, goldenrod, and aster was evaluated again September 24, 2010 (30 DAT).

All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Fisher's protected LSD.

RESULTS AND DISCUSSION

Prior to the spring treatment, ground coverage by the target species varied as follows: chicory 8 to 15 percent, goldenrod 4 to 10 percent, tall fescue 12 to 18 percent, and creeping red fescue 15 to 21 percent. Phytotoxicity to tall and fine fescue was observed with MAT28 plus Matrix and with Milestone VM plus Plateau (Table 1). Phytotoxicity remained evident on tall and fine fescue with both MAT28 plus Matrix treatment rates through 105 DAT. MAT28 at 1.88 plus Matrix at 2.00 oz/ac showed phytotoxicity values of 38 and 7 percent for tall and fine fescue, respectively. MAT28 at 3.00 plus Matrix at 3.00 oz/ac produced phytotoxicity values of 50 and 15 percent for tall and fine fescue, respectively.

At 31 DAT, all treatments resulted in statistically similar injury to chicory ranging from 78 to 96 percent (Table 2). Injury increased through 60 DAT for all treatments except Milestone VM plus Plateau. Treatments previously rated at 94 to 96 percent now yielded 100 percent injury, while other combinations ranged from 83 to 87 percent. At the final rating, 105 DAT, all treatments had eliminated chicory, while the untreated plot averaged 13 percent cover.

MAT28 plus Telar XP, Escort XP, or Matrix at 3.00 oz/ac produced the greatest injury to goldenrod among the treatments tested at 31 DAT (83 to 92 percent). Injury to goldenrod decreased for most treatments at 60 DAT. However, by 105 DAT there was no remaining goldenrod among the treatments, except Milestone VM plus Plateau (2 percent cover).

The fall-applied treatments (Table 3) resulted in variable amounts of injury to the desirable turf. At 16 DAT, MAT28 plus Telar XP or Escort XP caused the least discoloration on tall fescue (7 percent) and no symptoms on creeping red fescue. Both Milestone VM plus Escort XP and MAT28 plus Matrix treatments caused phytoxicity to tall fescue (17 and 27 percent). Only the MAT28 plus Matrix caused phytotoxicity on fine fescue (10 percent), though not statistically significant.

No statistical differences in injury for chicory, goldenrod, or aster were observed at either 16 or 30 DAT. At 30 DAT, injury values for chicory ranged from 96 to 100 percent; goldenrod injury was 50 to 72 percent; and aster injury was 43 to 60 percent.

CONCLUSIONS

At the rates tested in this study, MAT28 plus Escort XP or Telar XP provided excellent control of chicory. Control of goldenrod was greater and acceptable in the spring treatments using the MAT28 plus Escort XP or Telar XP combinations but only marginal for goldenrod and aster when applied in the fall. Further evaluation of these two species may be needed to determine whether more complete control is achieved over time.

No objectionable injury was observed on the desirable grasses with MAT28 plus Telar XP or Escort XP treatments. In contrast, Milestone VM plus Plateau (spring) or Escort XP (fall) caused initial and unacceptable injury to tall fescue, which recovered by 105 DAT (spring), with no injury to the fine fescues. The MAT28 plus Matrix combinations caused unacceptable injury to tall fescue at both treatment timings and fine fescue at the spring timing. Although the grasses appeared to recover over time, the initial effects deter the use of this combination for turf applications.

MANAGEMENT IMPLICATIONS

DuPont has released two new products containing MAT28 that are appropriate for selective weed control, premixing MAT28 with either Escort (*metsulfuron*) or Telar (*chlorsulfuron*). Streamline™ contains *aminocyclopyrachlor* (39.5 percent w/w) plus *metsulfuron* (12.6 percent w/w) and is best suited for controlling weeds and brush in the 7713 program, while also providing some safety to the grass understory at lower use rates. The rate of *metsulfuron* in Streamline is twice the rate used in the MAT28/Escort combinations in this study; therefore, there is a greater potential for damage to turf with Streamline. Perspective™ is a combination of *aminocyclopyrachlor* (39.5percent w/w) and *chlorsulfuron* (15.8 percent w/w) targeted for general broadleaf control within industrial turf areas. Prices at the time of publication are $82.40 and $70.04 per lb for Streamline and Perspective, respectively. Based on current contract prices, the cost of the herbicide mixes used in this study are similar, amounting to $12.26 to 24.51 for Streamline and $10.42 to 20.83 for Perspective at low (2.4 oz/ac) and high (4.8 oz/ac) rates, respectively, compared to $19.16 for the Milestone plus Escort mix and $14.80 for Milestone plus Plateau.

Streamline and Perspective should be tested prior to operational use to assure safety to turf and consistent weed control as compared to the facsimile mixes tested in this study.

Table 1. Tall fescue ("FESAR") and fine fescue ("FESXX") phytotoxicity were evaluated on June 28 (31 days after treatment, DAT), July 27 (60 DAT), and September 10, 2010 (105 DAT). All treatments included CWC Surfactant 90 at 0.25% v/v and were applied to industrial turf near Tyrone, PA on May 28, 2010. Each value is the mean of three replications. Differences between means were considered statistically significant at $p < 0.05$. ns = not significant.

		FESAR			FESXX		
product	rate	31 DAT	60 DAT	105 DAT	31 DAT	60 DAT	105 DAT
	oz/ac	-----% phytotoxicity-----			-----% phytotoxicity-----		
MAT28 Telar XP	1.88 0.50	0	0	0	0	0	0
MAT28 Telar XP	3.76 1.00	7	0	0	0	0	0
MAT28 Escort XP	1.88 0.25	0	0	0	0	0	0
Milestone VM Plateau	5.00 4.00	20	30	0	0	0	0
MAT28 Matrix	1.88 2.00	30	80	38	20	37	7
MAT28 Matrix	3.00 3.00	30	80	50	20	37	15
MAT28 Telar XP	3.76 0.50	0	0	0	0	0	0
Untreated	---	0	0	0	0	0	0
LSD (p=0.05)		8	7	14	15	10	ns

Table 2. Chicory ("CHIIN") and goldenrod ("SOLXX") injury were evaluated on June 28 (31 days after treatment, DAT), July 27 (60 DAT) and cover rated on September 10, 2010 (105 DAT). All treatments included CWC Surfactant 90 at 0.25% v/v and were applied to industrial turf near Tyrone, PA on May 28, 2010. Each value is the mean of three replications. Differences between means were considered statistically significant at $p < 0.05$. ns = not significant.

		CHIIN			SOLXX		
product	rate	31 DAT	60 DAT	105 DAT	31 DAT	60 DAT	105 DAT
	oz/ac	---% injury---		% cover	---% injury---		% cover
MAT28 Telar XP	1.88 0.50	83	85	0	87	87	0
MAT28 Telar XP	3.76 1.00	94	100	0	90	83	0
MAT28 Escort XP	1.88 0.25	95	100	0	92	96	0
Milestone VM Plateau	5.00 4.00	87	83	0	50	50	2
MAT28 Matrix	1.88 2.00	78	87	0	60	50	0
MAT28 Matrix	3.00 3.00	94	100	0	83	63	0
MAT28 Telar XP	3.76 0.50	96	100	0	87	77	0
Untreated	---	0	0	13	0	0	3
LSD (p=0.05)		ns	8	2	14	21	1

Table 3. Tall fescue ("FESAR") and fine fescue ("FESXX") phytotoxicity were evaluated on September 10 (16 days after treatment, DAT). Chicory ("CHIIN"), goldenrod ("SOLXX"), and aster ("ASTXX") injury were rated on September 10 (16 DAT) and September 24, 2010 (30 DAT). All treatments included CWC Surfactant 90 at 0.25% v/v and were applied to industrial turf near Tyrone, PA on August 25, 2010. Each value is the mean of three replications. Differences between means were considered statistically significant at $p < 0.05$. ns = not significant.

		FESAR	FESXX	CHIIN		SOLXX		ASTXX	
product	rate	16 DAT	16 DAT	16 DAT	30 DAT	16 DAT	30 DAT	16 DAT	30 DAT
	oz/ac	--% phytotoxicity--		--------------------------% injury--------------------------					
MAT28 Telar XP	3.76 1.00	7	0	87	96	65	68	47	43
MAT28 Escort XP	3.76 0.50	7	0	80	100	62	72	53	60
Milestone VM Escort XP	7.44 0.47	17	0	85	100	58	58	47	50
MAT28 Matrix	3.76 4.00	27	10	77	99	50	50	47	47
Untreated	---	0	0	0	0	0	0	0	0
LSD (p=0.05)		13	ns	ns	ns	ns	ns	ns	ns

EVALUATION OF AMINOCYCLOPYRACHLOR TANK MIXES COMPARED TO AMINOPYRALID FOR BROADLEAF WEED CONTROL

Herbicide trade and common names: Escort XP (*metsulfuron*), MAT28 (*aminocyclopyrachlor*), Milestone VM (*aminopyralid*), Telar XP (*chlorsulfuron*).
Plant common and scientific names: aster (*Asteraceae* spp.), broadleaf plantain (*Plantago major*), dandelion (*Taraxacum officinale*), creeping red fescue (*Festuca rubra*), Kentucky bluegrass (*Poa pratensis*), red clover (*Trifolium pratense*), tall fescue (*Festuca arundinacea*), wild carrot (*Daucus carota*).

ABSTRACT

A successful broadleaf weed control program is necessary in the management of industrial roadside turf. MAT28 is a new synthetic auxin introduced by DuPont that is expected to be available in combination with either Escort XP or Telar XP in 2011. An evaluation of the tank mix of these herbicides, in addition to Milestone VM alone or combined with Escort XP, was conducted. The safety to three turfgrass species and control of five dicot species was determined with applications made in spring or fall. MAT28 plus Escort XP and MAT28 plus Telar XP provided similar control of the dicots tested compared to the Milestone VM plus Escort XP treatment. Milestone VM alone did not as effectively control all the dicot species tested.

INTRODUCTION

A successful broadleaf weed control program with safety to the turf groundcover on the right-of-way is essential to maintaining traveler safety and roadside quality. In an effort to enhance broadleaf weed control with the latest tools and comparison of tank mixes representing soon to be available combination herbicide premixes were tested against commercial standards. MAT28, or aminocyclopyrachlor, is a new active ingredient developed by DuPont. The herbicide is a synthetic auxin within a new class of herbicides known as pyrimidine carboxylic acids. It controls a wide spectrum of broadleaf weeds, vines, and brush species, while being selective to grasses at low rates. It has soil activity with a potential half-life of 4 months.

Milestone VM was chosen as a comparison because it has a broad spectrum of activity on dicots, is labeled for use on most cool-season, perennial grasses in roadside areas, has low use rates, and maintains long residual activity in the soil to prevent germination of weed seeds.

MAT28 plus either Telar XP or Escort XP tank mixes were compared to Milestone VM with or without Escort XP applied in either the fall or spring. Phytotoxicity to turf and injury to select broadleaf species were evaluated.

MATERIALS AND METHODS

A trial was established along I-99 at the Bellwood interchange. Treatments included 3.76 oz/ac MAT28 plus 1 oz/ac Telar XP; 3.76 oz/ac MAT28 plus 0.5 oz/ac Escort XP; 7 oz/ac Milestone VM; 7 oz/ac Milestone VM plus 0.5 oz/ac Escort XP; and an untreated check. All treatments included 0.25% v/v Surfactant CWC 90.

Treatments were applied in the fall and spring to 24 by 30 ft. plots using a randomized complete block design and three replications. A CO_2-powered backpack sprayer equipped with a 6 ft. boom and four 8004 VS tips was used to apply the treatments at 40 gal/ac. Fall and spring treatments were applied on September 24, 2009 and May 6, 2010, respectively

Vegetative and broadleaf cover was rated for the fall-treated plots on September 25, 2009, 1 day after treatment, DAT. Percent injury to broadleaf weeds and turf was rated on October 21, 2009, 27 DAT. On May 7, 2010, 225 DAT, turf injury and broadleaf control were evaluated for individual species.

The spring-treated plots were rated May 6, 2010, 0 DAT for total cover and cover by species. Turf injury and broadleaf control for individual species was evaluated on June 7, August 7, and August 31, 2010, 32, 93, and 117 DAT.

All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Fisher's Protected LSD.

RESULTS AND DISCUSSION

The fall treatments initially had between 81 and 95 percent total green cover with 24 to 34 percent cover by dicots. At 27 days after treatment, DAT, injury to dicots ranged from 33 to 67 percent while turf injury was only evident in the MAT28 plus Escort XP treatment (10 percent). By 225 DAT, the turf injury was only seen on Kentucky bluegrass for the MAT28 plus Escort XP treatment (13 percent). Control of all individual dicot species evaluated was 100 percent for MAT28 plus Escort XP and ranged from 98 to 100 percent for MAT28 plus Telar XP and Milestone VM plus Escort XP. Control was significantly less for broadleaf plantain, aster, and dandelion using Milestone VM alone.

The spring treated plots averaged 70 to 77 percent total vegetative cover at time of treatment. While mostly grasses, the plots contained five targeted dicot species of which each accounted for 1 to 6 percent of the total cover. No injury was observed on either fine fescue or Kentucky bluegrass at 32 DAT; however, treatments containing Escort XP plus either MAT28 or Milestone resulted in 50 and 57 percent injury on tall fescue, respectively. Milestone VM or MAT28 plus Escort XP provided good to excellent control (87 to 100 percent) of all species evaluated, except wild carrot (50 percent). MAT28 plus Telar XP was also effective at controlling dicots with greater control of wild carrot (80 percent), compared to the treatments containing Escort XP. Percent control in treatments containing Milestone VM alone ranged from 23 to 100 percent among the five broadleaf species. No turf injury was evident for any treatment at 117 DAT. Escort XP plus either MAT28 or Milestone VM and MAT28 plus Telar XP provided nearly complete control of the dicots evaluated (98 to 100 percent).

CONCLUSIONS

MAT28 plus Escort XP and MAT28 plus Telar XP provided similar control of the dicots tested compared to the Milestone VM plus Escort XP treatment. These combinations appear to control the five broadleaf species evaluated. Caution should be observed when using combinations containing Escort XP on turf as injury may result at rates as low as 0.5 oz/ac. Milestone VM alone did not provide the same level of control to all tested dicot weed species as the MAT28 tank mixes.

MANAGEMENT IMPLICATIONS

The MAT28 plus Telar XP (*chlorsulfuron*) combination provides a greater margin of safety to the industrial turf common on the roadside while offering similar dicot control to MAT28 plus Escort XP (*metsulfuron*). Two new premixes containing these herbicides are available from DuPont. Streamline™ is a mix of *aminocyclopyrachlor* (39.5% w/w) plus *metsulfuron* (12.6% w/w). The rate of *metsulfuron* in Streamline is twice the rate used in the MAT28/Escort combinations in this study; therefore, there is a greater potential for damage to turf with Streamline. Perspective™ is a combination of *aminocyclopyrachlor* (39.5% w/w) and *chlorsulfuron* (15.8% w/w). The PA State Contract prices at the time of publication are $82.40 and $70.04 per lb for Streamline and Perspective, respectively. Based on current contract prices, the costs of the herbicide mixes used in this study are $24.51, 20.83, and 18.47 for Streamline at 4.8 oz/ac, Perspective at 4.8 oz/ac, and Milestone at 7 plus Escort at 0.5 oz/ac, respectively.

Streamline and Perspective should be tested prior to operational use to assure safety to turf and consistent weed control as compared to the facsimile mixes tested in this study.

Table 1: Visual ratings of percent injury to dicots and turf collected October 21, 2009, 27 days after treatment, DAT. Values represent an average of all dicot and turf species present within the plot. Percent control of broadleaf plantain (PLAMA), aster (ASTXX), red clover (TRIPR), dandelion (TAROF), and wild carrot (DAUCA) evaluated May 7, 2010, 225 DAT. Treatments were applied September 24, 2009. Each value is the mean of three replications. Differences between means were considered statistically significant at $p \leq 0.05$.

product	rate	dicot	turf	PLAMA	ASTXX	TRIPR	TAROF	DAUCA
	oz/ac	---% injury---		---------------------% control---------------------				
MAT28 Telar XP	3.76 1	58	0	100	100	100	98	100
MAT28 Escort XP	3.76 0.5	67	10	100	100	100	100	100
Milestone VM	7	33	0	50	50	100	63	100
Milestone VM Escort XP	7 0.5	33	0	99	99	100	98	100
LSD (p=0.05)		25	0	1	1	ns	24	ns

Table 2: Visual rating of percent injury to tall fescue (FESAR) and percent control of broadleaf plantain (PLAMA), aster (ASTXX), red clover (TRIPR), dandelion (TAROF), and wild carrot (DAUCA) were evaluated June 7 and August 31, 2010, 32 and 117 days after treatment, DAT. Treatments were applied May 6, 2010. Each value is the mean of three replications. Differences between means were considered statistically significant at p≤0.05. Column means followed by the same letter (DAUCA) are not significantly different according to Fisher's Protected LSD test. A single LSD value could not be reported due to unequal replication.

		FESAR		PLAMA		ASTXX		TRIPR		TAROF		DAUCA	
product	rate	32 DAT	117 DAT	32 DAT	117 DAT	32 DAT	117 DAT	32 DAT	117 DAT	32 DAT	117 DAT	32 DAT	117 DAT
	oz/ac	------% injury------		-----% control-----									
MAT28 Telar XP	3.76 1	7	0	90	100	95	100	100	100	100	100	80	99b
MAT28 Escort XP	3.76 0.5	50	0	90	100	92	100	98	100	100	100	50	100a
Milestone VM	7	0	0	50	85	63	80	100	100	100	100	23	80c
Milestone VM Escort XP	7 0.5	57	0	87	99	92	99	100	98	97	100	50	100a
LSD (p=0.05)		15	ns	6	9	24	1	ns	ns	ns	ns	ns	---

EVALUATION OF FALL-APPLIED HERBICIDES FOR REMOVAL OF POISON HEMLOCK FROM CROWNVETCH GROUNDCOVER

Herbicide trade and common names: Basagran T/O (*bentazon*), Clearcast (*imazamox*), GlyPro (*glyphosate*), Overdrive (*dicamba* + *diflufenzopyr*)
Plant common and scientific names: Canada thistle (*Cirsium arvense*), crownvetch (*Coronilla varia*), poison hemlock (*Conium maculatum*).

ABSTRACT

Poison hemlock (COIMA) presents a livestock hazard and commonly invades non-managed roadside areas established in crownvetch (CZRVA) or other low maintenance grass groundcovers. The challenge for roadside specialists is to control the poison hemlock while protecting the established groundcover. Basagran T/O, Clearcast, and Overdrive are non-crop or roadside labeled herbicides and have a potential to safely control poison hemlock. These products were evaluated alone or in combination using a fall-applied treatment. At 195 days after treatment, DAT, COIMA cover was significantly reduced by Overdrive at 4 and 8 oz/ac, Clearcast at 8 oz/ac, and Overdrive plus Clearcast at 4 oz/ac each, compared to the untreated check. However, COIMA cover had increased for all treatments with a proliferation of first-seedlings or uncontrolled rosettes except for Overdrive plus Clearcast, which was only marginally reduced. No treatments effectively controlled the COIMA at the site.

Prior work has suggested that spring-applied treatments of Velpar DF; Basagran T/O; or Velpar DF plus GlyPro may offer reduction of COIMA and a margin of safety to the CZRVA with a properly timed spray[1]. Repeated spring-applied treatments using a postemergence herbicide targeting rosettes and preemergence component to prevent first-year seedlings may offer a viable approach for future investigations.

INTRODUCTION

Poison hemlock (COIMA) is an exotic biennial that has become increasingly common on roadsides in unmanaged crownvetch (CZRVA) areas. The greatest concern with this plant is the lethal effects of ingestion to livestock and humans. As a biennial the challenge in managing this plant is preventing seed production while maintaining or restoring a competitive ground cover to limit further spread of the COIMA.

Two management approaches for removing COIMA would be to use selective chemistry to target the infested areas in CZRVA or to convert the area to a competitive grass ground cover. A conversion to grass would first require control of CZRVA, COIMA, and other unwanted species followed by seeding of desirable grasses. Long-term, annual selective sprays or mowing would be needed to discourage weeds and promote the grasses.

The premise of this trial was to preserve CZRVA and existing grasses while controlling COIMA. Targeting COIMA with a late-season application offers an additional window of opportunity after spray crews have completed the side-trimming program. Several herbicides and combinations were evaluated for selective control of COIMA. Basagran T/O was chosen based on prior work that determined safety to CZRVA and reduction of the COIMA stand following spring treatment.[1] Additionally, Clearcast and Overdrive were used based on the anticipated recovery of CZRVA, possible control of COIMA, and their labeling for non-crop areas.

MATERIALS AND METHODS

A randomized complete block designed trial with three replicate treatments of Overdrive or Clearcast alone at 4 and 8 oz/ac rates, combined at 4 oz/ac each, or each mixed at 4 oz/ac plus Basagran at 32 oz/ac, and an untreated check was established within a poison hemlock infested crownvetch stand on the shoulder of I-79 near Canonsburg, PA. Herbicide treatments included CWC Surfactant 90 at 0.25% v/v. All COIMA and taller Canada thistle stems were first snapped off by hand to accommodate the application equipment and applicator. The treatments were applied to 9 by 15 ft plots at a rate of 40 gal/ac on October 13, 2009 using a CO_2-powered backpack sprayer with 9 ft hand-held boom and six Teejet 8004VS even flat fan spray tips.

The study was visually rated for total cover, COIMA cover, and CZRVA cover on October 13, 2009, 0 days after treatment, DAT. Injury to COIMA (0 = no injury, 5 = moderate injury, 10= death) was assessed on Novermber 20, 2009, 38 DAT, and COIMA cover was evaluated on April 26, 2010, 195 DAT. All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Fisher’s protected LSD.

RESULTS AND DISCUSSION

At the time of application, the total cover ranged from 87 to 92 percent, COIMA cover 15 to 37 percent, and CZRVA cover 55 to 72 percent with no significant differences among treatments. At 38 DAT injury to COIMA was similar for all treatments, varying from 4 to 6, except for Clearcast at 4 oz/ac alone (3). When evaluated at 195 DAT, COIMA cover was significantly lower for Overdrive at 4 and 8 oz/ac, with 32 and 25 percent, respectively, Clearcast at 8 oz/ac (43 percent), and Overdrive plus Clearcast combined at 4 oz/ac each (20 percent) compared to the untreated check (65 percent). By this date, COIMA cover had increased for all treatments from a proliferation of first-year seedlings or uncontrolled rosettes, except Overdrive plus Clearcast (20 percent) and ranged from 25 to 63 percent.

CONCLUSIONS

None of the herbicide treatments effectively controlled the COIMA stand when fall-applied. Many of the plots treated with Overdrive alone, or in combination, eliminated the COIMA rosettes but did not prevent the spring flush of first-year seedlings.

MANAGEMENT IMPLICATIONS

The COIMA seed bank will not be eliminated by a single herbicide application, but previous work has suggested that spring-applied treatments of Velpar DF at 21 oz/ac; Basagran T/O at 32 oz/ac; or Velpar DF plus GlyPro at 21 and 24 oz/ac, respectively, may offer reduction of COIMA

[1] Gover, A.E. et al. 2005. Selective herbicide mixtures for control of poison hemlock in a crownvetch groundcover. Roadside Vegetation Management Research Annual Report – Nineteenth Year Report. pp. 31-36.

and a margin of safety to the CZRVA with a properly timed spray[1]. Repeated herbicide treatment may exhaust the existing seedbank, but the potential remains for seed to spread from outside of the application area. Even when rosettes are controlled, the fall-applied treatments result in a flush of COIMA seedlings the following spring. Further work is needed to determine if targeting the rosettes and adding a preemergence component using spring-applied treatments offers a viable approach.

Table 1: Poison hemlock (COIMA) and crownvetch (CZRVA) cover were visually rated on October 13, 2009 (0 days after treatment, DAT). COIMA injury was assessed on November 20, 2009, 38 DAT, and cover was evaluated on April 26, 2010, 195 DAT. All herbicide treatments included 0.25 % v/v CWC Surfactant 90 and were applied to a COIMA infested CZRVA stand located near Canonsburg, PA on October 13, 2009. Each value is the mean of three replications. Differences between means were considered statistically significant at p≤0.05.

		0 DAT		38 DAT	195 DAT
treatment	rate	COIMA	CZRVA	COIMA	COIMA
	oz/ac	----------% cover----------		--% injury--	--% cover--
untreated	---	18	68	0	65
Overdrive	4	23	65	4	32
Overdrive	8	15	72	4	25
Clearcast	4	25	60	3	63
Clearcast	8	25	55	5	43
Overdrive Clearcast	4 4	23	62	5	20
Overdrive Basagran T/O	4 32	37	43	6	53
Clearcast Basagran T/O	4 32	23	57	6	47
protected LSD (p=0.05)		ns	ns	2	21

COMPARISON OF NU-FILM-IR AND CWC SURFACTANT 90

Herbicide trade and common chemical names: Escort XP (*metsulfuron*), Garlon 3A (*triclopyr*), MAT28 (*aminocyclopyrachlor*), Milestone VM (*aminopyralid*), Overdrive (*dicamba*), Telar XP (*chlorsulfuron*)

Plant common and scientific names: Canada thistle (*Cirsium arvense*), crownvetch (*Coronilla varia*), Kentucky bluegrass (*Poa pratensis*), tall fescue (*Festuca arundinacea*)

ABSTRACT

Activator adjuvants complement herbicide mixtures by improving herbicidal activity, primarily in postemergence applications. The efficacy of two commercially available, non-ionic activator agents on Canada thistle was demonstrated, using three different herbicide mixtures at two locations. Herbicide treatments included Milestone VM at 7 plus Overdrive at 4 oz/ac; Garlon at 64 plus Escort at 0.5 oz/ac; and MAT28 at 3.4 plus Telar at 0.9 oz/ac. The two adjuvant treatments were NU-FILM-IR ("Nufilm") at 16 oz/100 gal and CWC Surfactant 90 ("CWC90") at 0.25 percent v/v. Based on visual injury ratings taken 19 days after treatment, DAT, and stem counts conducted at 228 DAT, there were no apparent differences between the performance of Nufilm and CWC90 on Canada thistle at either Salunga or Centerville for the three herbicide mixes deployed.

INTRODUCTION

Activator adjuvants complement herbicide mixtures by improving herbicidal activity, primarily in postemergence applications. They generally provide one or more of the following benefits: enhanced herbicide absorption by plant tissue, increased herbicide rainfastness, and reduced herbicide photodegradation. There are several different types of activator adjuvants, including surfactants, crop oil concentrates, spreader-stickers, wetting agents, penetrants, and nitrogen fertilizers[1].

The efficacy of two commercially available, non-ionic activator adjuvants on Canada thistle was demonstrated, using three different herbicide mixtures. Non-ionic molecules have no net charge and are therefore compatible with the majority of herbicide products[1]. NU-FILM-IR is composed of 96 percent Poly-1-p-Menthene and 4 percent inert ingredients and is described as a 'sticking agent', according to the label. The manufacturer suggests that NU-FILM-IR forms a "sticky-elastic film" on the plant foliage[2]. CWC Surfactant 90 is labled as 90 percent alkylarypolyoxethylene glycols, free fatty acids, and isopropanol with 10 percent inerts[3]. Surfactants reduce the surface tension of the spray solution, allowing droplets to spread more uniformly on the leaf surface[1].

[1] Curran, W.S. et al. 1999. Agronomy Facts 37 – Adjuvants for enhancing herbicide performance. College of Agricultural Sciences, Pennsylvania State University, 8 pp.
[2] Miller Chemical & Fertilizer Corporation Hanover, PA 17331.
[3] CWC Enterprises, Inc. Cloverdale, VA 24077.

MATERIALS AND METHODS

Two demonstrations were established to compare surfactant efficacy; the first was located in Salunga, PA at the junction of SR 283 and Spooky Nook Rd. The second demo was located west of Lancaster, PA at the interchange of SR 30 and Centerville Rd. Both sites were infested with Canada thistle and also supported a crownvetch groundcover. Tall fescue and Kentucky bluegrass were present only at Salunga. The layout followed a factorial design with three herbicide treatments and two activator adjuvants. Herbicide treatments included Milestone VM at 7 plus Overdrive at 4 oz/ac; Garlon at 64 plus Escort at 0.5 oz/ac; and MAT28 at 3.4 plus Telar at 0.9 oz/ac. The two adjuvant treatments were NU-FILM-IR ("Nufilm") at 16 oz/100 gal and CWC Surfactant 90 ("CWC90") at 0.25 percent v/v. One plot per treatment (i.e., six plots total) was established at each location. Plots were 36 by 36 ft in size. The treatments were applied on September 21, 2010 at 45 gal/ac using a CO_2-powered backpack sprayer with 6 ft boom and four 8004 VS tips at Centerville and an Echo motorized backpack sprayer with a Gunjet 30 equipped with an X-6 tip at Salunga.

Percent injury (0=no injury, 100=plant death) for Canada thistle and crownvetch were visually estimated at both locations on October 7, 2010, as well as percent injury to tall fescue and Kentucky bluegrass at Salunga. On May 26, 2011, Canada thistle stem counts were taken in two randomly-selected square meter subplots, and crownvetch ground cover was visually estimated within each subplot.

RESULTS AND DISCUSSION

Due to misapplication of the MAT28 at 3.4 plus Telar at 0.9 oz/ac treatment, data for that herbicide combination are not reported for Salunga. At 19 days after treatment, DAT, injury values varied more among the three herbicide treatments than between the two activator adjuvants within a single herbicide treatment (Table 1). Since treatments were not replicated within the demonstrations, means could not be compared statistically. It appeared that CWC90 was slightly more effective, in terms of initial injury, than Nufilm for the Milestone VM plus Overdrive mix applied at Centerville, while Nufilm performed marginally better when applied with Garlon 3A plus Escort. These differences are not surprising since the efficacy of the adjuvant varies with target weed species (e.g., due to variations in leaf wax composition) as well as herbicide chemistry[4]. Overall, the adjuvants produced similar injury to thistle, ranging from 50 to 75 percent, except for MAT28 plus Telar at Centerville (25 percent injury). Injury to crownvetch was also similar among adjuvants, and injury values for tall fescue and Kentucky bluegrass were identical.

At 228 DAT, thistle stems counts and crownvetch cover were similar between CWC90 and Nufilm for a given herbicide treatment (Table 2). Most of the variation occurred between sites, with much higher thistle stem counts at Salunga than Centerville, except for the Milestone VM plus Overdrive treatment. This difference is likely due to the fact that the two Milestone VM plus Overdrive plots were located in a separate, less-dense patch of thistle at Salunga relative to the other herbicide treatment reported.

[4] Curran, W.S. et al. 1999. Agronomy Facts 37 – Adjuvants for enhancing herbicide performance. College of Agricultural Sciences, Pennsylvania State University, 8 pp.

CONCLUSIONS

There were no apparent differences between the performance of Nufilm and CWC90 on Canada thistle at either Salunga or Centerville for the three herbicide mixes demonstrated.

MANAGEMENT IMPLICATIONS

Nufilm at 16 oz/100 gal and CWC90 at 0.25 percent v/v produced similar results when used with Milestone VM at 7 plus Overdrive at 4 oz/ac; Garlon at 64 plus Escort at 0.5 oz/ac; and MAT28 at 3.4 plus Telar at 0.9 oz/ac. It should be noted that adjuvant performance may vary with different herbicide mixes. The cost for Nufilm is currently \$32.00/gal[5] while CWC90 is \$8.76/gal[6]. This would equate to \$4.00/100 gal mixed solution for Nufilm and \$2.19/100 gal mixed solution for CWC90 at the rates tested in these demonstrations (i.e., 16 oz/100 gal and 32 oz/100 gal, respectively). Based on the similar results between the two surfactants the cost and herbicide activity should be considered in making the decision on surfactant.

[5] Cost of \$32.00/gallon quoted June 2011 by Gary Wakefield, Miller Chemical and Fertilizer Corporation.
[6] Cost obtained from 2010 PA State Herbicide Contract.

Table 1. Visual estimates of injury (0=no injury, 100=plant death) evaluated on October 7, 2010, to Canada thistle ("CIRAR") and crownvetch ("CZRVA") at Centreville and Salunga, PA, as well as percent injury to tall fescue ("FESAR") and Kentucky bluegrass ("KBG") for Salunga only. Treatments consisted of a factorial design with three herbicide mixes and two activator adjuvants and were applied on September 21, 2010 at 45 gal/ac. Due to misapplication of the MAT28 at 3.4 plus Telar at 0.9 oz/ac treatment, data for that herbicide combination are not reported for Salunga. Each value represents a single observation.

			Centerville		Salunga			
Herbicide Mix	Rate	Adjuvant	CIRAR	CZRVA	CIRAR	FESAR	KBG	CZRVA
	oz/ac		% injury					
Milestone VM +	7	CWC90	75	75	75	0	0	90
Overdrive	4	Nufilm	50	50	75	0	0	95
Garlon 3A +	64	CWC90	50	75	50	10	10	98
Escort	0.5	Nufilm	75	75	50	10	10	95
MAT28 +	3.4	CWC90	25	35	---	---	---	---
Telar	0.9	Nufilm	25	25	---	---	---	---

Table 2. Stem counts for Canada thistle ("CIRAR") and visual estimates of crownvetch ("CZRVA") ground cover as evaluated on May 26, 2011, at Centreville and Salunga, PA. Treatments consisted of a factorial design with three herbicide mixes and two activator adjuvants and were applied on September 21, 2010 at 45 gal/ac. Due to misapplication of the MAT28 at 3.4 plus Telar at 0.9 oz/ac treatment, data for that herbicide combination are not reported for Salunga. Each value represents the mean of two-randomly selected square meter subplots.

			Centerville		Salunga	
Herbicide Mix	Rate	Adjuvant	CIRAR	CZRVA	CIRAR	CZRVA
	oz/ac		# stems	% cover	# stems	% cover
Milestone VM +	7	CWC90	25	3	0	0
Overdrive	4	Nufilm	4	1	7	0
Garlon 3A +	64	CWC90	8	0	61	0
Escort	0.5	Nufilm	1	0	50	0
MAT28 +	3.4	CWC90	0	18	---	---
Telar	0.9	Nufilm	14	6	---	---

ASSESSING THE INHIBITOR EFFECT OF JAPANESE KNOTWEED LITTER EXTRACT ON GERMINATION AND SEEDLING GROWTH UNDER LABORATORY BIOASSAY CONDITIONS

Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), creeping red fescue (*Festuca rubra*), Japanese knotweed (*Polygonum cuspidatum*), spring oats (*Avena sativa*), tall fescue (*Festuca arundinacea*).

ABSTRACT

Allelopathic inhibition provides a mechanistic explanation for the poor grass establishment observed at some Japanese knotweed reclamation sites. Knotweed has a robust potential to inhibit other species due to its high annual biomass production and turnover, as well as its extensive rhizome system. Allelochemicals, if present, may leach from residue into the soil and inhibit growth of a desirable groundcover. Knotweed leaf litter and organic soil were extracted in water, and the leachate from these materials was then applied under laboratory conditions in petri plate based germination systems and soil-based seedling bioassay systems to screen for allelochemical inhibition of spring oats, annual rye, and creeping red fescue. Results from the germination experiment indicated that Japanese knotweed litter extract may have an inhibitory effect on creeping red fescue but not spring oats or annual rye. Knotweed soil extract appeared to enhance germination, possibly due to microbes present in the soil and/or a relatively high N content. In the soil bioassays, fertilizer was added to one set of the leachate treatments to assure that nutrient limitation did not inhibit seedling growth. Although there was initially a significant interaction between knotweed leaf litter leachate and fertilizer, results did not indicate allelopathic effects from the leachate under the controlled environment conditions. It is possible that the allelochemical effects on germination and growth of creeping red fescue may be more severe under the stressful conditions of the natural environment. Future research could focus on the potential for exudates from knotweed rhizomes to allelopathically inhibit creeping red fescue.

INTRODUCTION

Japanese knotweed is a rhizomatous, aggressively-growing herbaceous perennial plant. Knotweed has become a threat on roadsides where dense monoculture stands can exceed ten feet in height and pose a risk to sight distance and safety. Japanese knotweed is also regarded as an invasive species due to its aggressive rhizomatic spread along streamsides and in infested fill material used along roadways and its ability to crowd out preferred species.

Previous work has demonstrated that a multi-step approach, based on chemical methods, can effectively control knotweed[1]. If the management approach includes revegetation with grasses, knotweed resprouts can be selectively targeted with a broadleaf herbicide. In order to eradicate the knotweed, which can continue to sprout from rhizomes, annual retreatment is often required for several years. Unfortunately, establishment of competitive grass groundcover in these operational control sequences has presented a challenge[2].

[1] Gover, A.E. et al. 2000. Evaluation of Giant Knotweed Control and Conversion into Fine Fescues. Roadside Vegetation Management Research Report – Thirteenth Year Report, pp. 17-18.
[2] Johnson, J.G. et al. 2009. Implementing Japanese Knotweed Removal and Conversion to Grasses. Roadside Vegetation Management Research Report, pp. 26-28.

Allelopathic inhibition provides a mechanistic explanation for the poor grass establishment that has been observed following chemical suppression of knotweed. Allelochemicals can be released as exudates from living tissue and/or leached from plant residues[3]. Knotweed has a robust potential to inhibit other species due to its high annual biomass production and turnover, as well as its extensive rhizome system. At the ecosystem scale, it is likely that chemicals released from accumulated knotweed residue (i.e., litter) produce allelopathic effects in soil. At present, the allelopathic properties of knotweed require further characterization[4].

Prior research with knotweed-infested soil showed no differences in germination of annual rye or tall fescue seeds between infested and uninfested soils[5]. As the next step in exploring possible allelopathic interactions, knotweed leaf litter and organic soil were extracted in water. The leachate from these materials was then applied in laboratory culture and soil-based systems to screen for potential effects on the germination of spring oats, annual rye, and creeping red fescue in culture and on both the germination and growth of creeping red fescue seedlings in soil. These three grass species are commonly used for revegetation and erosion control.

MATERIALS AND METHODS

Knotweed litter and organic matter collection. Brown foliage and undecomposed leaf litter were collected from a Japanese knotweed stand located east of Tyrone on I-99 on October 1, 2010. The knotweed stand was free of trees and other overstory species. In addition to leaf litter, a sample of material from the organic soil horizon was collected. The organic soil consisted of dark brown to black humus up to 1 cm in depth. Samples were air-dried at room temperature. Litter was sorted to remove leaves from other species and then ground in a Wiley Mill using a 1-mm mesh. Fine roots were removed from the organic soil, which was then passed through a 2 mm sieve and finally ground to a fine powder in a coffee grinder. Processed leaf litter and organic soil samples were stored in plastic bags.

Extraction. Ground samples of leaf litter (25 g) and soil (100 g) were extracted in 1 L distilled water. Extracts were mixed on an orbital shaker at 1500 RPM for 24 hr at 21 C. The mixtures were taken off the shaker and inverted periodically. Samples were filtered first through a double-layer of cheesecloth and then Whatman No. 1 filter paper and stored at 4 C. Leachate samples were submitted to the Penn State Agricultural Analytical Services Lab for analysis of percent solids, organic matter, pH, soluble salts, total nitrogen, and total carbon.

Germination study. All seed was obtained from Ernst Conservation Seeds (Meadville, PA). Oat seed was placed in 9-cm diameter petri dishes with three Whatman No. 2 filter papers and 7.5 mL of treatment solution. Annual rye and fine fescue were incubated with two filter papers and 5 mL solution. Twenty five seeds were used for each of four replicates in a completely randomized design. Treatments included a control (water), litter leachate, and soil leachate. Seeds were incubated for three to seven days at 21 C, and the number of germinated seeds, those that had 2 mm or more radicle protruding, was recorded on a daily basis. Data were

[3] Putnam A.R. and C.S. Tang. 1986. Allelopathy: state of the science. In: The Science of Allelopathy. John Wiley & Sons, New York, 1–19.
[4] Weston, L.A. et al. 2005. A review of the biology and ecology of three invasive perennials in New York State. Plant Soil 277, 53-69.
[5] Johnson, J.M. et al. 2010. Germination of Annual Rye and Tall Fescue in Knotweed Infested Soil. Roadside Vegetation Management Research Report, pp. 61-65.

subjected to analysis of variance, and when treatment effect F-tests were significant ($p < 0.05$), treatment means were compared using Fisher's Protected LSD.

Seedling bioassay. Soil was collected on December 3, 2010 from a fallow organic field at the Russell E. Larson Agricultural Research Farm (Rock Springs, PA). Samples were acquired from a depth of 0 to 5 cm, air-dried, sieved to 4-mm, and homogenized. The soil was a clay loam with 2.2 percent organic matter (Penn State Agricultural Analytical Services Lab).

Trays (15 by 10 by 5 cm) were prepared with 250 g growth medium (75 percent field soil and 25 percent white silica sand, v/v). Creeping red fescue was planted at a rate of 15 lbs per acre, the equivalent of 28 seeds per tray. Seedlings were grown in a growth room under constant light at 21 C and were watered daily or every-other-day to maintain field capacity. Two sets of experimental treatments were investigated.

In order to test the effects of leachate addition and fertilization on fescue germination and growth, a completely randomized 2 by 2 factorial design with four replications was employed. Fertilizer was added to ensure that growth was not limited by nutrient deficiency. The two leachate treatments were a control (distilled water) and a leachate (25 g leaf litter per L), and the fertilizer treatments were a control (distilled water) and a nutrient solution (1 tbsp 20-10-10 granular fertilizer per L). For each tray, 75 mL of either distilled water (control) or leachate was added with an additional 9 mL of either water (control) or nutrient solution to bring the soil to field capacity. For the remainder of the thirteen-day growth period, soil was maintained at field capacity with the addition of distilled water only.

The effect of prolonged leachate exposure was tested by administering three treatments with five replications as follows: control (distilled water), 50 percent leachate solution (12.5 g leaf litter per L), and 100 percent leachate solution (25 g leaf litter per L). The three treatments were applied for six consecutive days in the volume needed to maintain the soil at field capacity, approximately 30 mL per day, after which distilled water only was added to all treatments.

For the seedling bioassays, the number of shoots was counted thirteen days after planting, and shoot biomass was harvested, dried, and weighed. Data from the factorial seedling bioassay, which incorporated both leachate and fertilization treatment, were fit with a least squares model, with leachate, fertilizer, and the interaction between leachate and fertilizer as main effects. Data from the second trial was subjected to analysis of variance, and when treatment effect F-tests were significant ($p < 0.05$), treatment means were compared using Fisher's Protected LSD.

RESULTS AND DISCUSSION

Germination study. Leachate from knotweed-infested organic soil and knotweed leaf litter were applied to seeds of spring oats, annual rye, and creeping red fescue. Leachate chemistry is reported in Table 1. In general, radicle growth from the seeds was primarily oriented toward the bottom of the dish in leachate treatments, whereas in control treatments, radicles also grew toward the lid of the dish. Nutrients contained in the leachate (Table 1) likely attracted roots toward the saturated filter paper, even though some water had evaporated and condensed on the lids of the dishes. There were no significant differences in germination for annual rye or spring oats (Table 2). However, germination of creeping red fescue was significantly lower on day 4 through day 6 for the litter leachate relative to the control or soil leachate. By day 7, there were no longer significant differences in fescue germination among the treatments, but the radicles appeared to have been stunted by the litter leachate. Overall, germination tended to be highest in the soil extract; it is likely that germination was enhanced by either the higher N content of the soil extract (i.e., soil extract carbon: nitrogen (C:N) 6.6 vs. leaf litter extract C:N 22; Table 1), microbes present in the soil which could help break down the seed coat, or a combination of both factors. Among the three species tested, creeping red fescue appeared to be the most susceptible to potential allelopathic effects of knotweed litter extract, which is not surprising since fescue seeds (454,087 seeds/lb) are smaller than spring oats (19,400 seeds/lb) and annual rye (217,000 seeds/lb)[6].

Seedling bioassay. In order to further investigate the allelopathic potential of knotweed, creeping red fescue was grown in a soil medium with leaf litter leachate treatments. Results from the factorial experiment (Table 3) indicated that leachate alone did not have a significant effect on either the number of shoots (i.e., the number of germinated seeds) or shoot biomass, while fertilizer did affect the number of shoots ($p<0.04$). Additionally, there was a significant interaction between leachate and fertilizer on the number of shoots ($p<0.02$) and shoot dry weight ($p<0.01$). Without fertilizer, leachate significantly decreased the number of shoots ($p<0.02$), whereas leachate had no effect on the number of shoots when fertilizer was added. It is possible that the addition of the leachate, which would provide a labile carbon source for microbes, reduced nitrogen availability during the germination period. However, the addition of fertilizer to the control treatment (i.e., increased nutrient availability) actually decreased the number of shoots as well as shoot biomass. Shoot biomass was greater for the leachate treatment than the control with the addition of fertilizer, indicating that combination of leachate and fertilizer enhanced fescue growth. Overall, these results did not indicate that the leachate treatment had antagonistic effects on fescue biomass.

In a second experiment, three different leachate treatments were applied for a period of six days in order to increase exposure to allelochemicals, if present in the leachate. There were no significant differences in shoot number or biomass among treatments (Table 4); therefore, the leachate treatments alone did not inhibit fescue germination or growth in the soil bioassay.

CONCLUSIONS

The germination study indicated that Japanese knotweed litter extract may have an inhibitory effect on the germination of creeping red fescue seeds but not spring oats or annual rye. Knotweed soil extract actually tended to enhance germination, likely due to microbes present in the soil and/or a relatively high N content.

Seedling bioassays were performed with creeping red fescue and Japanese knotweed leaf litter extract. Although there was initially a significant interaction between knotweed leaf litter leachate and fertilizer, results did not indicate allelopathic effects from the leachate under the experimental conditions. It is possible that the effects of allelochemicals, if present, may have been more pronounced under greater stress from factors such as drought, nutrient deficiency, temperature, and light intensity[7]. Plants growing in natural environments generally experience greater stress than under controlled conditions. The clay loam/sand growth medium utilized in the current experiment provided both nutrients and a high water holding capacity. Since the soil was collected from the field, the microbes present could have degraded allelochemicals, if present in the leachate, and have prevented allelopathic effects on fescue. However, the experimental system employed was designed to represent field conditions as closely as possible

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[6] 'Seed per Pound' figures retrieved from the USDA Plants database < http://plants.usda.gov/>.

[7] Millar, J. G. and K. F. Haynes. 1998. Methods in Chemical Ecology: Bioassay methods. Kluwer Academic Publishers. Norwell, Massachusetts. 432 pp.

in order to realistically evaluate the effects of knotweed litter leachate on the germination and growth of creeping red fescue.

Future research could focus on the potential for exudates from knotweed rhizomes to allelopathically inhibit creeping red fescue. Due to its small seeds, creeping red fescue should be more susceptible than species like spring oats and annual rye and therefore provides more sensitivity when testing for potential allelopathic effects.

MANAGEMENT IMPLICATIONS

Although we did not observe allelopathic effects in our experimental system, it is possible that allelochemicals and/or other factors could inhibit the growth of desirable groundcover during the revegetation of knotweed reclamation sites. For example, the accumulation of knotweed litter and residue on the soil surface could decrease the amount of light available to seedlings. The removal of litter prior to seeding would not only increase light availability but would also decrease the chance of allelochemicals, if present, leaching out of knotweed residue. If the removal of litter is not practical, it may be useful to delay seeding for a season or more following chemical treatments or to seed at a reduced rate initially, followed by additional seeding as the knotweed litter naturally degrades.

Table 1. Results of leachate analysis for Japanese knotweed leaf litter and organic soil on both a wet and dry weight basis. Leaf litter and organic soil were dried, ground, and 25 and 100 g of litter and soil, respectively, were extracted in 1 L distilled water for 24 h at 21 C and then filtered. C:N = carbon to nitrogen ratio.

Parameter	Litter (wet)	Litter (dry)	Soil (wet)	Soil (dry)
pH	6.6		7.2	
	---------------------- %	----------------------	----------------------	----------------------
Solids	0.2		0.1	
Moisture	99.8		99.9	
Organic matter	0.20	85	0.10	66
Total nitrogen	0.0045	2.1	0.01	6.2
Carbon	0.10	47	0.066	41
C:N	22	22	6.6	6.6

Table 2. Results of germination trials. The number of germinated seeds out of 25 total seeds is reported for creeping red fescue, annual rye, and spring oats. Seeds were germinated in petri dishes with either water ('Control'), Japanese knotweed litter leachate ('Litter'), or Japanese knotweed infested organic soil leachate ('Soil'). Each value is the mean of four replications. Differences between means were considered statistically significant at $p \leq 0.05$. ns = not significant.

Species	Treatment	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
		---------------------- # germinated seeds ----------------------					
Creeping red fescue	Control	---	1	16	22	22	23
	Litter	---	0	10	16	19	23
	Soil	---	2	14	22	24	24
Protected LSD		---	ns	4	4	2	ns
Annual rye	Control	---	24	24	24	---	---
	Litter	---	22	24	24	---	---
	Soil	---	23	24	24	---	---
Protected LSD		---	ns	ns	ns	---	---
Spring oats	Control	21	24	---	---	---	---
	Litter	21	24	---	---	---	---
	Soil	21	24	---	---	---	---
Protected LSD		ns	ns	---	---	---	---

Table 3. Creeping red fescue seeds were planted in a soil medium and received factorial treatments of either distilled water ('Control') or knotweed leaf litter leachate ('Leachate') both with ('Yes') and without fertilizer ('No'). The number of shoots was counted thirteen days from planting, and shoot biomass was harvested, dried, and weighed. Each value is the mean of four replications. P-values from a least squares model are reported.

Treatment	Fertilizer	Shoots	Biomass
		#	mg
Control	Yes	21.0	12.0
Control	No	25.8	14.3
Leachate	Yes	22.5	15.4
Leachate	No	22.3	12.2
Model Effect		------- p-value -------	
Leachate		0.320	0.509
Fertilizer		0.038	0.619
Leachate*Fertilizer		0.023	0.009

Table 4. Creeping red fescue seeds were planted in a soil medium and received three treatments, distilled water ('Control - 0'), 50 percent strength knotweed litter leachate ('Leachate – 50'), or 100 percent strength knotweed litter leachate ('Leachate – 100'). The number of shoots was counted thirteen days from planting, and shoot biomass was harvested, dried, and weighed. Each value is the mean of five replications. Differences between means were considered statistically significant at $p \leq 0.05$. ns = not significant.

Treatment	Shoots	Biomass
	#	mg
Control - 0	17.6	7.72
Leachate - 50	17.4	8.72
Leachate - 100	20.4	8.42
Protected LSD	ns	ns

GLYPHOSATE PROVIDES MORE CONSISTENT SUPPRESSION OF JAPANESE KNOTWEED THAN TRICLOPYR WHEN APPLIED SEQUENTIALLY OR FOLLOWING CUTTING

Herbicide trade and common chemical names: Aquaneat (*glyphosate*), Garlon 3A (*triclopyr*)
Plant common and scientific names: Japanese knotweed (*Polygonum cuspidatum* = *Fallopia japonica*)

ABSTRACT

Japanese knotweed was treated with two-operation treatments in 2008 and 2009, comparing cutting alone to combinations including glyphosate or triclopyr at 3 lb ae/ac. Cutting alone did not reduce fresh weight biomass compared to untreated plots. In 2009, herbicide treatments were applied under three different treatment regimes; twice-sprayed plots were treated either May 6 and September 9 or July 23 and September 9, and cut-then-spray plots were treated June 2 and September 9. All glyphosate applications resulted in the least amount of regrowth and lowest stem densities. Triclopyr (3 lb ae/ac) applied in the same manner as glyphosate resulted in significantly higher stem densities than glyphosate treatments and fresh weights that were higher but not significantly different.

INTRODUCTION

Japanese knotweed is a rhizomatous, herbaceous perennial that grows in tall, dense stands that impede motorist sight distance and access to roadside areas. Previous trials have demonstrated the utility of glyphosate applied to intact knotweed late in the growing season[1], or to well-developed regrowth[2] following a June cutting. Glyphosate has no soil activity, has aquatic labeling, and is familiar to consumers. However, it is non-selective, so care is required to limit injury to non-target plants. In previous trials, single applications of triclopyr have shown no utility against knotweed[1]. However, triclopyr is largely safe to grasses, and is available in aquatic-labeled products. Developing a viable control program using triclopyr would provide reduced environmental risk similar to glyphosate while being a grass-safe option to facilitate ground cover reestablishment. The objective of this trial was to evaluate triclopyr in a two-operation treatment scenario to determine if it could be as effective as glyphosate. In 2008, the operations were cutting alone, cut followed by late season herbicide, or sequential herbicide application (July and September). In 2009, a sequential herbicide application treatment (May and September) was added to determine if a spring herbicide treatment would provide the same benefit of reduced canopy afforded by the cut-then-treat regimen. A spray application to emerging knotweed is quicker than cutting and could result in time savings if the canopy reduction is similar to cutting.

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[1] Control of Japanese Knotweed with Late-season Foliar Herbicide Applications. 2005. Roadside Vegetation Management Research Report – 19th Year Report. Pages 20-22.

[2] Johnson, J.M., A.E. Gover, and L.J. Kuhns. 2007. Evaluation of Herbicides for Control of Japanese Knotweed. Proceedings of the Northeast Weed Science Society. 61: 74-75. http://www.newss.org/proceedings/proceedings_2007.pdf

MATERIALS AND METHODS

The study was located at Milton State Park, an island in the West Branch of the Susquehanna River, between Milton and West Milton, PA.

2008 Trial

Plots were 15 by 25 ft, arranged in a randomized complete block with three replications. The treatments included an untreated control, cutting twice, cutting followed by application of Aquaneat at 3 qts/ac or Garlon 3A at 4 qts/ac, or two applications of Aquaneat at 3 qts/ac or Garlon 3A at 4 qts/ac. The cutting-only plots were cut to ground level June 18 and July 21, 2008; the cut-then-spray plots were cut to ground June 18 and sprayed September 30, 2008; and the twice-sprayed plots were treated July 21 and September 30, 2008. The July herbicide treatments were applied at a total volume of 185 gal/ac, and the September treatments were applied in a total of 92 gal/ac. Each application included surfactant[3] at 2 qts/ac. The herbicide treatments were mixed for each plot and applied with a CO_2-powered sprayer equipped with a TeeJet #5500 Adjustable ConeJet nozzle with an X-18 tip for the July applications and a X-12 tip for the September applications. The intact knotweed canopy heights ranged from 7 to 13 ft. Two of the replications were on the east side of a wide north-south trail and received more light. These plots had 10 to 13 ft canopies. The third replication was on the west side of the trail and was shaded in the afternoon, and had 7 to 8 ft canopies. After cutting, the knotweed in the September-sprayed plots regrew to 3 to 5 ft.

Initial stem counts were collected in each plot within a 5 by 5 ft sub-plot prior to initiation of treatments on May18, 2008. Response data included a visual rating of percent canopy reduction on May 8, 2009, and a fresh weight harvest and stem count of the sub-plot on June 2, 2009. Data were subjected to analysis of variance. Four plots in one of the replications were lost due to a tree fall, so mean comparisons had to account for unequal replication.

2009 Trial

In 2009, a sequential herbicide treatment evaluating a May plus September herbicide application was added to the treatments applied in 2008. The cutting-only plots were treated May 6 and July 23, 2009, cut-then-treat plots on June 2 and September 9, the spring sequential treatment on May 6 and September 9, and the conventional sequential treatment on July 23 and September 9. The treatments were applied to 12 by 20 ft plots arranged in a randomized complete block with three replications. The May 6 treatments were applied at a carrier volume of 80 gal/ac to plots ranging from 15 to 45 percent cover, with stem heights ranging from emerging to 6.5 ft. The July 23 and September 9 treatments were applied at a carrier volume of 135 gal/ac. The July treatments were applied to intact, 6 to 9 ft tall canopies, while the September-treated plots were more variable, with canopy heights of 3 to 9 ft and cover values of 15 to 100 percent. Canopy reduction was visually rated June 16, 2010, and a fresh weight harvest and stem count was taken September 24, 2010 from permanent 5 by 5 ft subplots and converted to lbs fresh wt/square yard (SY). Data were subjected to analysis of variance and means separated using Fisher's Protected L.S.D. test when treatment effects were significant.

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[3] Competitor Modified Vegetable Oil, Wilbur Ellis Company.

RESULTS AND DISCUSSION

2008 Trial

Knotweed response to the 2008 treatments is summarized in Table 1. There were no significant differences between pre-treatment stem counts. The untreated plots averaged 13 stems/square yard (SY) prior to treatment and 12 stems/SY with 9.9 lbs fresh wt/SY on June 2, 2009. The twice-cut plots changed from 16 to 23 stems/SY, were rated at 30 percent canopy reduction, and averaged 8.9 lb/SY on June 2, 2009. The stem density in the twice-cut plots was significantly higher than in the untreated, but the fresh weights were not significantly different. The cutting regimen created a shorter, denser stand of knotweed the following season.

The herbicide-treated plots averaged 90 to 99 percent canopy reduction on May 8, 2009, with no significant differences among the four treatments. All herbicide treatments resulted in significantly greater canopy reduction than the twice-cut treatment and significantly reduced fresh weight harvest compared to no treatment or cutting alone. The Garlon 3A-treated plots (2.5, 2.4 lb/SY) averaged more fresh weight than the Aquaneat plots (0.6, 0.3 lb/SY), but there were no significant differences among the herbicide treatments. Post-treatment stem counts revealed higher stem densities among Garlon 3A-treated plots than Aquaneat-treated plots with no significant difference compared to untreated plots.

2009 Trial

Significant differences occurred between the herbicide treatments but not between the treatment sequences for a given herbicide (Table 2). The Aquaneat treatments averaged between 97 and 98 percent canopy reduction, significantly higher than all other treatments (data not shown). The Garlon 3A treatments ranged from 35 to 52 percent reduction and were not significantly different from each other. Cutting twice resulted in a 20 percent canopy reduction. The untreated check averaged 3.3 lb fresh weight and the twice-cut plots averaged 6.4 lb/SY. The Aquaneat-treated plots yielded 0.04 to 0.3 lb/SY, and the Garlon 3A-treated plots averaged 1.4 to 2.9 lb/SY. Compared to the untreated plots, the Aquaneat treatments reduced fresh weight biomass 90 to 99 percent, while the Garlon 3A treatments reduced fresh weight 11 to 56 percent. Different than the 2008 trial, Aquaneat-treated plots had significantly less biomass and stem density than Garlon 3A-treated plots. Canopy heights in September 2009 were similar for the cut-then-treat and spring sequential herbicide treatments, confirming the utility of a spring herbicide application as an alternative to a June mowing.

CONCLUSIONS

In both years of the trial, the glyphosate treatments resulted in near-elimination of Japanese knotweed. Triclopyr treatments provided a similar response to glyphosate in 2008 but were significantly less effective than glyphosate in 2009. Response to the 2008 treatments was measured in June 2009, while the 2009 treatments were evaluated in September 2010. The later measurements were intended to capture any recovery growth that might occur after treatment. After collection of the 2008 trial in data in June 2009, it appeared that perhaps the triclopyr treatments were beginning to recover, as the June biomass measurements seemed to reflect less suppression than the May 2009 visual ratings of canopy reduction. The positive results from the triclopyr treatments in 2008 were the first instance we have observed good control, but results from the 2009 treatments reflected the lack of efficacy we have previously observed. We have not resolved the response difference to triclopyr from 2008 and 2009 at this site. However, at this time we feel the 2009 results are more accurate, as they match observations from multiple trials, including observations of Garlon 3A plus Escort applications to roadside knotweed.

MANAGEMENT IMPLICATIONS

Even in a multiple-operation control program, triclopyr does not offer the utility of glyphosate to suppress Japanese knotweed. Effective management of Japanese knotweed is a multi-year effort, from initial control to revegetation. Glyphosate provides the most useful option for initial control, and triclopyr utility appears to be limited to the early application in a spring-sequential treatment and as a maintenance application to selectively suppress controlled-knotweed regrowth in grass groundcover.

Table 1. Japanese knotweed was subjected to two control operations during 2008. Twice cut plots were cut June 18 and July 21. Twice sprayed plots were treated July 21 and September 30, and cut-then-spray plots were treated June 18 and September 30. Pre-treatment stem counts were taken May 18, 2008, and post-treatment stem counts were taken June 2, 2009. Percent canopy reduction was rated May 8, and sub-plot fresh weight was measured June 2, 2009. Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test. A single L.S.D value could not be used due to unequal replications because four plots were lost due to a tree fall. Means are the average of two or three replications.

treatment	May 22, 2008 stem count	May 8, 2009 canopy reduction	June 2, 2009 stem count	June 2, 2009 fresh weight
	stems/SY	%	stems/SY	lbs/SY
untreated	13	0 c	12 b	9.9 a
cut twice	16	30 b	23 a	8.9 a
Aquaneat 2X	13	99 a	2 c	0.6 b
Garlon 3A 2X	15	90 a	8 b	2.5 b
cut/Aquaneat	12	90 a	1 c	0.3 b
cut/Garlon 3A	15	94 a	11 b	2.4 b

Table 2. Japanese knotweed was subjected to seven two-operation suppression treatments during 2009. Twice-cut plots were cut May 6 and July 23. Twice-sprayed plots were treated May 6 and September 9, or July 23 and September 9, and cut-then-spray plots were treated June 2 and September 9. Pre-treatment stem counts were taken May 6, 2009, and post-treatment stem counts and fresh weight biomass measurements were taken September 24, 2010. Canopy height was measured September 9, 2009. Each value is the mean of three replications. ns = not significant.

Treatment	May 6, 2009 stem count	Sep 9, 2009 canopy height	Sep 24, 2010 stem count	Sep 24, 2010 fresh weight
	stems/SY	ft	stems/SY	lbs/SY
Untreated	7.1	7.5	5.3	3.3
cut twice	19.5	3.6	9.8	6.4
Aquaneat May/Sep	15.1	4.9	0.6	0.3
Garlon 3A May/Sep	11.7	3.9	5.0	1.4
cut/Aquaneat	15.3	3.6	1.1	0.2
cut/Garlon 3A	12.7	3.9	6.4	2.3
Aquaneat Jul/Sep	17.9	7.2	1.0	0.0
Garlon 3A Jul/Sep	16.4	7.9	6.3	2.9
Protected LSD ($p < 0.05$)	ns	1.6	4.9	1.8

BAREGROUND COMPARISON USING COMMON TANK MIXES

Herbicide trade and common names: AquaNeat (*glyphosate*), Karmex XP (*diuron*), Krovar I (*diuron* + *bromacil*), Payload (*flumioxazin*), Oust Extra (*sulfometuron* + *metsulfuron*), Pendulum AC (*pendimethalin*), Plateau (*imazapic*), ProClipse 65WDG (*prodiamine*), Throttle XP (*chlorsulfuron* + *sulfometuron* + *sulfentrazone*)
Plant common and scientific names: bedstraw (*Galium* spp.), birdsfoot trefoil (*Lotus corniculatus*), common teasel (*Dipsacus fullonum*), crownvetch (*Coronilla varia*), smooth brome (*Bromus inermis*), switchgrass (*Panicum virgatum*), wild carrot (*Daucus carota*), wild parsnip (*Pastinaca sativa*), yellow toadflax (*Linaria vulgaris*).

INTRODUCTION

There are many viable herbicide combinations for bareground weed control under guiderails, around signposts, and along concrete barriers and traffic islands. The main factors that influence selection of mixes include herbicide availability and pricing, rotation of herbicides with different modes-of-action, and the presence of herbicide resistant or difficult to control weed species. In general, bareground mixes contain broad-spectrum residual as well as preemergence, and postemergence components. The broad-spectrum herbicide provides control of existing vegetation as well as soil residual activity. Preemergence herbicides are relatively immobile in the soil and are vital to prevent weed establishment from seed through the duration of the growing season. Postemergence herbicides are required only when green vegetation is present at the time of application.

Eight potential tank mixes, using chemistry most of which is available on the PA State Herbicide Contract, were demonstrated at a guiderail site which was overrun with perennial plant species. Evaluation of preemergence longevity and spectrum was the long-term goal of this test. The preemergence herbicides tested were *diuron* (Karmex, Krovar), *flumioxazin* (Payload), *pendimethalin* (Pendulum), *imazapic* (Plateau), *prodiamine* (Proclipse), and *sulfentrazone* (Throttle XP). Broad-spectrum activity in the mixes was provided by either *bromacil* (Krovar I), sulfometuron plus *metsulfuron* (Oust Extra), or *chlorsulfuron* plus sulfometuron (Throttle XP).

MATERIALS AND METHODS

This study was established along SR 1008 in Blair County near Bellwood, PA. Treatments include 4 oz/ac Oust Extra plus 128 oz/ac Karmex XP, 8 oz/ac Payload, 134 oz/ac Pendulum AC, 12 oz/ac Plateau, or 36.8 ProClipse 65WDG; 3 oz/ac Oust Extra plus 80 oz/ac Krovar I; 128 oz/ac Krovar I; and 12.5 oz/ac Throttle XP. All treatments included 96 oz/ac of AquaNeat. Treatments were applied to 4 by 25 ft. plots on May 14, 2010 and May 19, 2010 using a CO_2 powered backpack sprayer equipped with a ULV wand and OC-12 tip.

Percentage total green cover and control was rated on June 16 and July 19, 28 and 61 days after treatment, DAT, respectively.

RESULTS AND DISCUSSION

The mid-May application, which included glyphosate as a postemergence component in all mixes, was successful at eliminating plants present at treatment, allowing a good comparison of preemergence activity. Early evaluations, 28 and 61 days after treatment, did not show signs of annual weed development within the treated areas. The preliminary data suggests that all treatments controlled the existing weed population. The Krovar I treatment alone showed a subtle, but not significant, reduction in initial control relative to the other treatments due to a single plot that received a 70 percent control rating while the same treatment in the two remaining plots received 95 and 99 percent control at 28 DAT. The 61 DAT ratings revealed that the Krovar I treatment had finally and effectively controlled the existing vegetation within that single plot and was not significantly different from other treatments.

CONCLUSIONS

The glyphosate added to the treatments successfully controlled the heavy perennial population that existed at the time of application, and there were no detectable differences in vegetative cover or control among the herbicide mixes at 61 DAT.

MANAGEMENT IMPLICATIONS

The treatment options compared in this trial should provide adequate control of existing weed populations while maintaining acceptable preemergence control for a variety of common weed species. The mid-May timing allowed for prior green up of the perennial, warm-season switchgrass present at this site. One issue facing roadside managers is the increasing population of warm-season grasses that may establish within the guiderail area. Typically early season treatments are applied prior to new growth of warm-season grass species, and their perennial root systems are uninhibited by the standard bareground mixes. Where they are present, a later treatment containing glyphosate is necessary to gain control.

Table 1: Total green vegetative cover (total cover) and percent control were evaluated June 16 and July 19, 2010, which corresponds to 28 and 61 days after treatment, DAT. Treatments were applied to a roadside guiderail location near Bellwood, PA on May 14 or 19, 2010. All treatments included 96 oz/ac AquaNeat and 0.25% v/v CWC 90 surfactant. Each value is the mean of three replications. Differences between means were considered statistically significant at $p \leq 0.05$. ns = not significant.

		total cover	control	total cover	control
treatment	rate	28 DAT		61 DAT	
	oz/ac	-------------%-------------		-------------%-------------	
Oust Extra Karmex XP	4 128	1	99	3	98
Oust Extra Krovar I	3 80	1	98	3	97
Oust Extra Payload	4 8	1	98	4	97
Oust Extra Pendulum AC	4 134	1	98	1	99
Oust Extra Plateau	4 12	1	97	3	98
Oust Extra ProClipse 65WDG	4 36.8	1	96	4	96
Krovar I	128	2	88	3	97
Throttle XP	12.5	1	98	2	98
protected LSD (p=0.05)		ns	ns	ns	ns

MAT28 IN COMBINATION WITH PREEMERGENCE HERBICIDES FOR SEASON-LONG BAREGROUND WEED CONTROL

Herbicide trade and common chemical names: Authority (*sulfentrazone*), Goal 2XL (*oxyfluorfen*), Karmex (*diuron*), MAT28 50SG (*aminocyclopyrachlor*), Matrix (*rimsulfuron*), Prowl (*pendimethalin*), Surflan (*oryzalin*), Valor (*flumioxazin*).

Plant common and scientific names: annual sow thistle (*Sonchus oleraceus*), barnyardgrass (*Echinochloa crus-galli*), bearded sprangletop (*Leptochloa fascicularis*), bluegrass (*Poa* spp.), Canada thistle (*Cirsium arvense*), flower of an hour (*Hibiscus trionum*), foxtail (*Setaria* spp.), goldenrod (*Solidago* spp.), kochia (*Kochia scoparia*), orchardgrass (*Dactylis glomerata*), prickly lettuce (*Lactuca serriola*), quackgrass (*Agropyron repens*), wild carrot (*Daucus carota*).

ABSTRACT

The germination period for annual weeds, such as foxtails and kochia, often exceeds the length of residual activity offered by typical herbicide tank mixes. Therefore, bareground mixes should include an effective preemergence specific herbicide in addition to a broad spectrum postemergence herbicide with soil residual activity. MAT28, a new synthetic auxin, was applied at 4 to 6 oz/ac in combination with *glyphosate* and several different preemergence herbicides to evaluate the effectiveness of each tank mix for total vegetation control. At 120 days after treatment, DAT, those treatments containing MAT28 plus either Surflan at 96, Prowl at 63, Goal at 64, or Authority at 5.3 oz/ac had significantly lower total vegetative cover than MAT28 plus Karmex at 40 oz/ac; however, there were no significant differences in kochia cover (0 to 1 percent) among the MAT28 treatment combinations. Increasing the rate of MAT28 from 4 to 6 oz/ac decreased average kochia cover from 1 to 0 percent and limited the height of the few remaining kochia plants. Overall, Surflan and Prowl performed best against annual grasses among the preemergence options. The combination of MAT28 at up to 6 oz/ac plus Karmex at 40 oz/ac failed to provide sufficient residual control of annual grasses; since MAT28 is selective to grasses, it should be mixed with either an additional broad spectrum residual herbicide or a preemergence material that will control annual grasses, such as Surflan or Prowl.

INTRODUCTION

Season-long maintenance of bareground presents a challenge for single-application herbicide programs. The germination period for some annual weeds, such as foxtails and kochia, extends beyond the length of residual activity offered by typical herbicide tank mixes. Bareground mixes contain three components: a postemergence herbicide, a broad-spectrum residual, and a preemergence herbicide. *Glyphosate* is the most commonly used postemergence herbicide, which is needed only when green vegetation is present at the time of application. The broad-spectrum residual (BSR) component provides both postemergence and soil residual activity. Typical BSRs include Oust XP (*sulfometuron*), Krovar I (*bromacil*), and Arsenal *(imazapyr*); these chemicals have the potential for off-site movement, so it is standard practice to minimize use rates. DuPont has recently developed a new chemical, MAT28, and plans to label this synthetic auxin for the bareground market. MAT28 (*aminocyclopyrachlor*) is a broad-spectrum herbicide belonging to the new chemical class “pyrimidine carboxylic acids”. MAT28 may prove to be a useful component of bareground mixes if it provides sufficient residual activity; however, since MAT28 is selective to grasses, it is vital to include an effective preemergence herbicide with MAT28.

Preemergence herbicides include several different modes-of-action. *Oxyfluorfen* (Goal 2XL) is a cell membrane disrupter and is therefore included among those chemicals referred to as "contact" herbicides. Although not commonly used in roadside applications, Goal exhibits some postemergence activity but is most effectively applied to the soil surface for control of emerging seedlings. *Rimsulfuron* (Matrix) is an ALS inhibitor; many species, including kochia, have developed resistance to herbicides in this class of chemistry[1]. *Pendimethalin* (Prowl) and *oryzalin* (Surflan) are cell-division, or root inhibitors, and act only on germinating seeds. As PPO-inhibitors, both *sulfentrazone* (Authority) and *flumioxazin* (Valor) exhibit soil activity and can be used to control germinating annual weeds, as well as for burndown.

MAT28 was applied in combination with *glyphosate* and different preemergence herbicides to evaluate the effectiveness of each tank mix for season-long total vegetation control.

MATERIALS AND METHODS

A trial encompassing fourteen treatments was established in the median of SR322 in State College, PA. The treatments included: MAT 28 (WDG 50%) at both 4 and 6 oz/ac rates mixed with either Matrix at 4, Goal 2XL at 64, Surflan AS at 96, Prowl at 63, or Karmex at 40 oz/ac; MAT 28 at 4 oz/ac with either Valor at 7.8 or Authority at 5.3 oz/ac; Prowl alone at 63 oz/ac; and an untreated check. All herbicide treatments included *glyphosate* at 2 lb ae/ac (i.e., AquaNeat at 2 qts/ac) and CWC Surfactant 90 at 0.5% v/v. The treatments were applied to 6 by 15 ft plots in a randomized complete block design with three replications and were delivered at a rate of 50 gal/ac on April 22, 2010 using a CO_2-powered backpack sprayer with 6 ft boom and four Teejet 8004VS even flat fan spray tips. Species present at the time of application included bluegrass, wild carrot, Canada thistle, quackgrass, orchardgrass, annual sowthistle, goldenrod, and annual grass seedlings. *Glyphosate* was reapplied at 2 lb ae/ac with 0.5% v/v CWC Surfactant 90 at a rate of 50 gal/ac, using the same application equipment as the initial treatment, on May 10, 2010 to eliminate vegetation that had escaped the first treatment.

The study was visually rated for total cover and kochia cover on April 24, May 7, May 24, June 18, July 22, and August 20, 2010, which corresponds to 0, 13, 32, 55, 91, and 120 days after treatment (DAT), respectively. Kochia control (0 = no injury, 100 = death) was also assessed on May 7, May 24, and June 18; however, kochia skeletons had disappeared by July 22, and therefore, control could no longer be visually estimated.

All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Fisher's Protected LSD.

RESULTS AND DISCUSSION

At the time of application on April 22, 2010, total cover ranged from 1 to 4 percent, and kochia seedlings had already begun to germinate with 0 to 2 percent cover and no significant differences among plots. The initial application failed to completely eliminate the existing vegetation by 13 DAT, with up to 2 and 1 percent total and kochia cover, respectively, remaining

[1] Heap, I. International Survey of Herbicide Resistant Weeds. Accessed October 7, 2010. http://www.weedscience.com.

on the treated plots; the untreated check had 8 and 5 percent total and kochia cover, respectively. In order to test the preemergence activity of the treatments, a second application of *glyphosate* only was made on May 10, 18 DAT. The second treatment eliminated existing kochia on all treated plots. Bluegrass was the only species which survived the repeated *glyphosate* treatments, although it was severely injured.

At 32 DAT, all treatments had significantly lower total cover (0 to 2 percent) than the untreated check (11 percent; Table 1). Mean kochia cover was 0 percent on all treated plots, also significantly less than the untreated check (5 percent). Control values for kochia ranged from 99 to 100 percent among treatments containing MAT28; however, Prowl applied without MAT28 provided only 70 percent control, and although the mean kochia cover for the treatment was 0 percent, two of the three plots had surviving kochia seedlings, with 0.1 and 1 percent kochia cover. Total and kochia cover showed little change on treated plots through 55 DAT and increased to 18 and 7 percent, respectively, for the untreated plots. Kochia control improved to 99 percent for Prowl and 100 percent for all other treatments during the interval. At 91 DAT, total cover had increased among several of the treatments, with a maximum of 14 percent, largely due to the growth of annual grasses, including foxtails, barnyardgrass, and sprangletop. Broadleaf species present were primarily wild carrot, sow thistle, flower of an hour, prickly lettuce, and Canada thistle. Notably, MAT28 in combination with either Surflan or Prowl had significantly lower total cover (0 to 1 percent) than MAT28 plus Karmex (9 to 14 percent). Kochia cover remained at 0 percent for all treatments except for Prowl alone (3 percent) and increased to 10 percent for the untreated check. The efficacy of the treatments against late-season annual grass germination was even more apparent at 120 DAT, with Surflan and Prowl performing best. Treatments containing MAT28 plus either Surflan, Prowl, Goal, or Authority had significantly lower total cover than MAT28 plus Karmex; however, there were no significant differences in kochia cover (0 to 1 percent) among the MAT28 treatment combinations. The addition of MAT28 at either 4 or 6 oz/ac did significantly decrease kochia cover relative to Prowl plus *glyphosate* alone. An increase in the rate of MAT28 from 4 to 6 oz/ac reduced kochia cover from 1 to 0 percent and also tended to decrease kochia height among the plants remaining in the plots (data not shown). It is likely that the second *glyphosate* application on May 10 decreased the impact the added MAT28 would have had on control of kochia and other broadleaf species.

Previous work has shown that in areas with high kochia pressure, *sulfentrazone* may provide the greatest control of actively growing kochia[2]. In the present trial, Valor and Authority both provided excellent kochia control when combined with MAT28 at the 4 oz/ac rate. Other research showed that the combination of MAT28 at 7.5 oz/ac plus Oust at 3 oz/ac with either Karmex at 16, Chateau (*flumioxazin*, 51 WDG, Valent Corporation) at 10, or Authority at 8 oz/ac provided the best control of kochia through 168 days (0 to 1 percent kochia cover) as well as total vegetation control (5 to 9 percent cover).[3]

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[2]Johnson, J.M. et al. 2009. Further evaluation of alternatives to diuron for kochia control. Roadside Vegetation Management Research Annual Report. p.45.

[3]Johnson, J.M. et al. 2010. Aminocyclopyrachlor for bareground and suppression of kochia . Roadside Vegetation Management Research Annual Report. p. 22.

CONCLUSIONS

Among the preemergence herbicides tested in combination with MAT28, Surflan and Prowl performed best and had significantly less cover than MAT28 plus Karmex at end of season. Surflan and Prowl have also provided good annual grass suppression in previous research[4]. While Authority, Goal, Matrix, and Valor provide some postemergence activity, Surflan and Prowl are not the best choices where perennial vegetation dominates (e.g., quackgrass, orchardgrass, smooth brome) since they act only on germinating seeds.

All MAT28 treatments provided excellent preemergence control of kochia. However, the second application of *glyphosate* at 64 oz/ac on May 10 likely limited kochia pressure relative to a standard operational setting. For example, current operational practices are generally limited to a single early-season application of *glyphosate* at 64 oz/ac. Therefore, operational mixes must contain a BSR with sufficient postemergence and residual activity to provide control beyond the initial *glyphosate* application. The combination of MAT28 at up to 6 oz/ac plus Karmex at 40 oz/ac failed to provide sufficient residual control of annual grasses; since MAT28 is selective to grasses, it should be mixed with either an additional BSR or a preemergence material that will control annual grasses, such as Surflan or Prowl.

MANAGEMENT IMPLICATIONS

MAT28 offers potential as a tank-mix partner for bareground weed control, especially for control of resistant broadleaf weed species like kochia. The EPA issued conditional approvals for four MAT28 premixes on August 30, 2010, and the new brands are expected to be released to the market in 2011. DuPont's Plainview™, a combination of *aminocyclopyrachlor, sulfometuron,* and *chlorsulfuron,* may provide another option for bareground programs; however, the cost of the new material is currently unknown. The addition of *sulfometuron* will increase the mix's spectrum of activity, especially against grasses. When considering preemergence components, the equivalent active ingredient in Surflan and Prowl would cost $38.24[5] and $24.09[6], respectively, at the rates used in this study. However, Surflan and Prowl should be used with caution in high-visibility areas where public perception is a concern, due to their bright color and potential to cause short-term staining (i.e., days or more) of pavement and other treated surfaces, such as guiderails.

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[4]Johnson, J.M. et al. 2010. Suppression of annual grasses along highway guiderails. Roadside Vegetation Management Research Annual Report – Twenty-fourth Year Report. p.30.

[5]Cost of $47.80/gallon in 2.5 gallon container quoted January 2010 by Arborchem, Inc., Mechanicsburg, PA. Price quote was for Oryzalin 4 Pro manufactured by Quali-Pro, Raleigh, NC. Generic equivalent of Surflan AS.

[6]Cost obtained from 2010 PA State Herbicide Contract.

Table 1. Total and kochia ("KCHSC") percent cover were visually rated on May 24 (32 days after treatment, DAT), June18 (55 DAT), July 22 (91 DAT), and August 20, 2010 (120 DAT). All herbicide treatments included Aquaneat at 64 oz/ac and were applied to a roadside guiderail location in State College, PA on April 22, 2009. Aquaneat was reapplied at 64 oz/ac on May 10, 2010 to eliminate vegetation that had escaped the initial treatment. Each value is the mean of three replications. Differences between means were considered statistically significant at $p \leq 0.05$.

		32 DAT		55 DAT		91 DAT		120 DAT	
Product	Rate	Total	KCHSC	Total	KCHSC	Total	KCHSC	Total	KCHSC
	oz/ac	------------------------------ % Cover ------------------------------							
MAT28 Matrix	4 4	1	0	0	0	4	0	9	1
MAT28 Matrix	6 4	1	0	2	0	10	0	17	0
MAT28 Goal 2XL	4 64	0	0	1	0	4	0	9	1
MAT28 Goal 2XL	6 64	0	0	1	0	4	0	15	0
MAT28 Valor	4 7.8	0	0	0	0	6	0	20	0
MAT28 Authority	4 5.3	1	0	2	0	7	0	15	0
MAT28 Surflan AS	4 96	0	0	0	0	1	0	4	1
MAT28 Surflan AS	6 96	0	0	1	0	0	0	1	0
MAT28 Prowl	4 63	1	0	1	0	1	0	4	1
MAT28 Prowl	6 63	0	0	0	0	0	0	3	0
MAT28 Karmex	4 40	1	0	0	0	9	0	33	1
MAT28 Karmex	6 40	1	0	1	0	14	0	37	0
Prowl	63	2	0	1	0	5	3	13	9
Untreated	---	11	5	18	7	25	10	33	15
LSD (p<0.05)		2	2	2	2	7	4	17	7

NATIVE SEED MIX ESTABLISHMENT IMPLEMENTATION – YEAR THREE

Plant common and scientific names: autumn bentgrass (*Agrostis perennans*), big bluestem (*Andropogon gerardii*), black-eyed susan (*Rudbeckia hirta*), Canada wildrye (*Elymus canadensis*), Chewing's fescue (*Festuca rubra* var. *commutata*), coltsfoot (*Tussilago farfara*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), early goldenrod (*Solidago juncea*), fine fescue (*Festuca rubra*), giant foxtail (*Setaria faberi*), hard fescue (*Festuca brevipila*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparius*), ox-eye sunflower (*Heliopsis helianthoides*), partridge pea (*Chamaecrista fasciculata*), sheep fescue (*Festuca ovina*), spring oats (*Avena sativa*), switchgrass (*Panicum virgatum*)

ABSTRACT

Formula N, a native warm-season grass (WSG) mix, was broadcast and hydroseeded at two sites in 2008. Results from the third year after seeding are encouraging with establishment rates of up to 1 plant per ft^2. The most successful species were big bluestem, little bluestem, Indiangrass, and switchgrass, which had matured and produced seedheads. Although Canada wildrye established in a few sporadic, dense clusters where hydroseeded at Homer City, neither wildrye nor autumn bentgrass provided satisfactory intermediate cover within three years after seeding. At the Montour Co. location, WSG had established within tufts of existing fine fescue. These results suggest that fine fescues may provide a better option for intermediate cover in WSG mixes. However, further testing is required to determine the utility of these non-native, cool-season species. The long-term success of WSG mixes at both sites will continue to be monitored.

INTRODUCTION

Warm-season grass (WSG) plantings often require several years to establish. Formula N (Table 1) is a native WSG mix currently under evaluation as an alternative to Formula C. Formula C has been criticized due to the potential for its crownvetch component to become invasive. In 2008, two application methods, hydroseeding and broadcasting, were employed to demonstrate the versatility of Formula N as an alternative seed mix. Background information, including an explanation of the components in Formula N, is provided in the Roadside Vegetation Management Research Twenty-Third Year Report[1], and evaluations from the second year of growth are summarized separately[2]. Results from the third year after seeding are reported here.

MATERIALS AND METHODS

The native seed mix implementation had been established in 2008 at two locations, along I-80W in Montour County and at a stockpile along SR56 near Homer City, PA. Both sites had a

[1]Johnson et al. 2009. Native Seed Mix Establishment Implementation. Roadside Vegetation Management Research Report - Twenty-third Year Report. pp. 50-53.

[2]Johnson et al. 2010. Native Seed Mix Establishment Implementation – Second Year Report. Roadside Vegetation Management Research Report. pp. 43-45.

steeply graded slope with poor, erosion-prone soil. In Montour County, half of the site was broadcast and the other half hydroseeded with Formula N on April 29. In addition to broadcast and hydroseeding applications of Formula N, Formula C (i.e., 19 lb/ac crownvetch and 24 lb/ac annual ryegrass) and Formula L (i.e., 63 lb/ac hard fescue, 41 lb/ac creeping red fescue, and 12 lb/ac annual ryegrass) were also hydroseeded in Homer City on April 30. Amendments were applied according to PennDOT Pub. 408, section 804 specifications. Hydroseeding was performed as a one-step process, in which seed, mulch, and soil amendments were mixed and applied together as a slurry. Floc-Lock tackifier (Lesco) was added to the hydroseed mixture at a rate of 3 lb/acre. Broadcast plots included seed and amendments but were not mulched.

In addition to previously reported evaluations from 2008 and 2009, the Montour Co. and Homer City sites were evaluated for establishment success on July 21 and August 3, 2010, respectively. Plant densities were visually estimated.

RESULTS AND DISCUSSION

At Montour Co., the hydroseeded area showed poor and sporadic WSG establishment. Only one partridge pea plant was observed. In the broadcast section, little bluestem, big bluestem, Indiangrass, and switchgrass were present. A few WSG plants had produced seedheads. Notably, some of the seedlings had established in existing tufts of fine fescue. It is likely that many seeds had been lost via runoff and erosion from the lower part of the slope prior to germination. No forbs were present in the broadcast area. Maximum seedling density in the broadcast section occurred on the upper part of the slope and was estimated at up to 1 plant per ft^2; however, establishment over the entire slope was much lower. The effects of fertilization in 2008 were still apparent on fine fescue within the seeded area relative to fescue outside of the implementation. Interestingly, WSG plants remained green while the fine fescue had largely browned out as a result of dry conditions.

The Homer City implementation showed encouraging results in both the hydroseeded and broadcast areas. Unfortunately, the bottom 10 ft of the slope had been mowed and could not be evaluated. Otherwise, the hydroseeded portion showed good establishment of native grasses in areas without competing cover, which was mostly crownvetch, goldenrod, and coltsfoot. Fine fescue was also present, which may have resulted from contamination during the hydroseeding process (i.e., Formula L was hydroseeded before Formula N). In areas free of competition, the estimated native density was approximately 1 plant per ft^2, though some smaller patches had much higher establishment rates. The uneven distribution of plants is likely a result of either inconsistent hydroseeding application and/or small-scale differences in soil quality (i.e., the native plants tend to do better in poorer soil where there is less competition from weeds). Canada wildrye, a cool-season species intended to provide intermediate cover, had established well and produced seedheads in the previously mentioned patches. Other species present were big bluestem, switchgrass, little bluestem, Indiangrass, and partridge pea.

The portion of the Homer City implementation that had been broadcast with Formula N also showed good establishment, with switchgrass, big bluestem, and little bluestem producing abundant seedheads. It appeared that Indiangrass might produce seedheads later in the season. Overall, the broadcast area tended to have a lower plant density than the hydroseeded portion, except for the upper, flatter part of the slope, but plants were generally more mature (i.e., larger and more frequently producing seedheads). Soils in the broadcast area appeared to have more loose shale than the hydroseeded section, which may explain why plants were more sparsely distributed. Plant density was visually-estimated at 0.4 plants per ft^2 for the lower, shale-dominated part of the slope, with a greater density above. There was a thick patch of partridge pea in flower on a flat section, mid-way up the slope, which should provide a seed bank to ensure survival of the annual legume. Few wildrye seedheads were observed, but overall, there was a diverse distribution of WSG species. Crownvetch was beginning to invade from the neighboring plot that had been seeded to Formula C.

For comparison, the area that had been seeded to Formula L in 2008 had established poorly, with a maximum of 5 to 10 percent cover. In fact, the slope was mostly bare except for foxtail. Alternatively, the section that received Formula C was nearly 100 percent crownvetch cover.

CONCLUSIONS

The fact that WSG species had matured and produced seed by the third year of growth is encouraging, especially on the steep, loose shale banks found at both sites. At Homer City, both the hydroseeded and broadcast native plantings outperformed Formula L, which did not establish in the dry conditions. At Montour Co., seedlings were concentrated on the upper part of the slope, and many of the seeds had germinated within and were growing through tufts of fine fescue. The maximum seedling density observed there was nearly one plant per ft^2 which was also noted in patches of the hydroseeded area at Homer City and meets the expectations for WSG species. As the plants mature, they will spread laterally and provide sufficient cover for erosion control. They will also produce a dense, deep growing root system.

The broadcast applications appear to have provided more consistent establishment than hydroseeding to date. Big bluestem, Indiangrass, and little bluestem have chaffy seed[3] that can become entrapped in the hydroseeding mulch. If these seeds germinate without contacting the mineral soil, the seedlings are likely to desiccate during dry conditions. Some WSG seeds did in fact remain trapped in the hydroseeding mulch at the end of the first season of growth[4]. As an alternative to typical one-step applications used for non-chaffy seed, in which seed, mulch, and amendments are mixed and applied together, seed can be applied first with a small amount of mulch for tracking, followed by the remainder of the mulch and soil amendments. Ideally, a two-step application will provide better seed-to-soil contact and increased germination and survival rates.

Canada wildrye, currently included as an intermediate component, failed to establish at Montour Co. and did not establish until the third year after seeding at Homer City. The other intermediate cover, autumn bentgrass, was not observed at either site. Therefore, a better companion cover is needed for the native seed mixes. Based on the results observed at Montour Co., fine fescues may offer a useful alternative as an intermediate cover in native-based mixes. Ideally, fescues will establish quickly and provide erosion control while the WSG species mature and ultimately take over. In fact, hard, chewing’s, and sheep fescues have been suggested as

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[3] Ugiansky, R.J. and C. Miller. 2008. Selection and Use of Native Warm-Season Grasses For The Mid-Atlantic Region. Maryland Plant Materials Technical Note No. 3. USDA-NRCS National Plant Materials Center, Beltsville, MD. 8 pp.

[4] Johnson et al. 2009. Native Seed Mix Establishment Implementation. Roadside Vegetation Management Research Report - Twenty-third Year Report. pp. 50-53.

potential companion species for short-term cover[5]. Further testing will be required to determine the utility of fine fescues as a cool-season, non-native intermediate component in WSG mixes. The long-term success of WSG species at both sites will continue to be monitored.

MANAGEMENT IMPLICATIONS

Results are encouraging for the use of WSG species in slope stabilization; however, a better intermediate cover is needed prior to operational use of the native WSG mixes.

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[5] Miller C.F. and J.A. Dickerson. 1999. The use of native warm season grasses for critical area stabilization. Proceedings of the 2nd Eastern Native Grass Symposium, Baltimore, MD. pp. 222-228.

Table 1. Formula N seed mix for the Montour County and Homer City slope rehabilitation projects. Components followed by an "*" are reported as lb/ac pure live seed (PLS). PLS = % germination x % purity / 100.

Common name	Scientific name	lb/ac
big bluestem	*Andropogon gerardii*	5.3*
little bluestem	*Schizachyrium scoparius*	5.3*
Indiangrass	*Sorghastrum nutans*	5.3*
switchgrass	*Panicum virgatum*	1.1*
Canada wildrye	*Elymus canadensis*	5.3*
autumn bentgrass	*Agrostis perennans*	11
spring oats	*Avena sativa*	64
partridge pea	*Chamaecrista fasciculata*	2.1
black-eyed susan	*Rudbeckia hirta*	0.53
ox eye sunflower	*Heliopsis helianthoides*	0.53
Total		100

SEASONAL TIMING EFFECTS ON WARM-SEASON GRASS ESTABLISHMENT RELATIVE TO CROWNVETCH AND ANNUAL RYEGRASS – YEAR TWO

Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), big bluestem (*Andropogon gerardii*), cereal rye (*Secale cereale*), crownvetch (*Coronilla varia*), foxtail (*Setaria* spp.), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), partridge pea (*Chamaecrista fasciculata)*, showy tick-trefoil (*Desmodium canadense*), spring oats (*Avena sativa*), switchgrass (*Panicum virgatum*), Virginia wildrye (*Elymus virginicus*).

ABSTRACT

In 2009, a replicated trial was installed to test the relative establishment of Formula N, a native seed mix, compared to Formula C, a standard mix of crownvetch and annual ryegrass used for poor sites and low-maintenance areas. The two mixes were planted on four dates, February 13, April 23, July 7, and August 21, using current establishment practices described in PennDOT Pub 408, Section 804. As of mid-August 2010, all Formula N plots and the February, July, and August seedings of Formula C remained dominated by weeds. Virginia wildrye cover was 12 and 18 percent for the February and April native seedings, respectively, and warm-season grass (WSG) seedlings were noticeable for both timings. Wildrye cover was 2 percent or less for the July and August seedings, which lacked visible WSG establishment. Overall, all plots except for the April seeding of Formula C (96 percent crownvetch cover) lacked sufficient perennial groundcover to meet PA Department of Environmental Protection standards. Either a more aggressive intermediate cover species is required and/or the seeding rates of Virginia wildrye must be increased in order to provide sufficient cover for erosion control. In critical areas, WSG plantings may require additional stabilization practices and temporary erosion and sediment control during establishment. This trial is an ongoing study and will require several years of monitoring to evaluate the establishment of the long-term WSG components of Formula N compared to Formula C establishment at the four seeding dates.

INTRODUCTION

Plant species used for revegetation tend to be invasive due to their ability to establish quickly in poor sites. Crownvetch, the long-term component of Formula C, has been listed as a "situational invasive" by the PA Department of Conservation and Natural Resources. Native warm-season grasses (WSG) provide an alternative to introduced species historically used for revegetation, but their ability to establish during unfavorable seeding dates (i.e., seeding is required at the completion of construction projects regardless of phenology) has not been evaluated. Characteristics of WSG have been described previously[1].

A trial was installed in 2009 to test the establishment of Formula N, a native seed mix, relative to PennDOT Formula C at four different planting dates[1]. Results from the second year after seeding are reported here.

MATERIALS AND METHODS

[1]Johnson et al. 2010. Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass. Roadside Vegetation Management Research Report - Twenty-fourth Year Report. pp. 57-60.

The study was established on a fill slope along I-99 northbound, west of State College, PA. The experiment followed a factorial design, consisting of two seed mixes (i.e., Formula N and Formula C) and four application timing windows (i.e., 1=Nov to Feb, 2=Mar to May, 3=Jun to July, and 4=Aug to Sep). The eight treatments were applied to 20 by 24 ft plots, arranged in a randomized complete block with three replications. Tables 1 and 2 list the components and seeding rates of Formula C and Formula N, respectively. Formula C and N were applied at a rate of 9.0 lb and 12.8 lb per 1000 S.Y., respectively. The four timings were seeded on February 13, April 23, July 7, and August 21, 2009. For a more detailed description of the site and methods, as well as results from the first year of growth, refer to Johnson et al.[2]

The site was evaluated in the second year after seeding on August 18, 2010. Virginia wildrye and crownvetch groundcover were visually-estimated. The presence or absence of WSG seedlings was noted for Formula N plots. Quantitative data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Fisher's Protected LSD.

RESULTS AND DISCUSSION

Visual estimates of Virginia wildrye and crownvetch groundcover are given in Table 3. Virginia wildrye, a native cool-season grass species, was the sole intermediate cover in the mix. The April seeding resulted in significantly higher wildrye cover (18 percent) than the February timing (12 percent). The July and August seedings had mean wildrye covers of 2 and 0 percent, respectively, which were significantly less than the February date. Although the April seeding had the greatest desirable cover, cover values were not high enough to provide satisfactory erosion control in the second year of growth. Spring oats, the annual cover, had germinated and died during the first year of growth in 2009. WSG seedlings were noted on all three replicate plots for both the February and April timings but were not apparent for either the July or August seedings (Table 3). As the WSG mature, percent cover will be determined; however, it is not possible to distinguish seedlings from abundant weedy, warm-season annual grasses (e.g., foxtails) when looking across the plot. A few individual partridge pea plants were observed among the timings, but their numbers were negligible. The potential for crownvetch (1 to 3 percent cover) to invade the native plots was expected since the plots are adjacent to one another.

As of August 2010, mean crownvetch cover followed the same trends observed for wildrye. The April seeding had significantly greater cover (96 percent) than February (17 percent), and the July and August timings had significantly less cover than February with 4 and 3 percent, respectively. A single plot from the April seeding was excluded as an outlier with 5 percent cover compared to 95 and 98 percent cover between the remaining two replicates. It is unknown why one replicate had only 5 percent cover. The highest crownvetch cover reported for any other timing was 20 percent, only a fraction of the values observed on the other two April-seeded plots (i.e., 95 and 98 percent), so it is unlikely that the April seed mix was applied to the wrong plot. However, the crownvetch inoculant was broadcast separately, one week after seeding, for the April timing since the supplier did not pre-mix the inoculant for that batch of seed[2]. Due to high winds when the inoculant was broadcast, it is possible that the fine powder may have been dispersed outside of the plot area.

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[2]Johnson et al. 2010. Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass. Roadside Vegetation Management Research Report – Twenty-fourth Year Report. pp. 57-60.

CONCLUSIONS

Since few WSG plants were established in 2009, those that germinated in 2010 likely remained in the seedling stage. Seedlings of WSG species were noted in Formula N plots planted in either February or April (1 percent cover or less) but not July or August. As the WSG mature, it will be easier to differentiate them from weedy warm-season annual grasses, such as foxtails.

Despite up to18 percent mean groundcover by Virginia wildrye, all Formula N timings and the February, July, and August seedings of Formula C remained dominated by weeds. Since the cover crops, annual rye and spring oats, had established and died off in 2009, all plots except for the April seeding of Formula C lacked sufficient perennial cover to meet PA Department of Environmental Protection standards:

> Vegetated areas shall be considered permanently stabilized when a uniform 70% vegetative cover of erosion resistant perennial species has been achieved, or the disturbed area is covered with an acceptable BMP which permanently minimizes accelerated erosion and sedimentation. Until such time as this standard is achieved, interim stabilization measures and temporary erosion and sediment control BMPs that are used to treat project runoff may not be removed[3].

However, it should be noted that when crownvetch forms a consistent groundcover, rill and gully erosion may occur underneath the canopy[4].

Recommended planting dates for WSG are December 1 to April 15 for Southern Pennsylvania and November 15 to May 1 for Northern Pennsylvania[5]. Late summer plantings (i.e., August to September) can result in delayed germination due to drought followed by winter kill of young seedlings[6]. In addition, some WSG species require freezing and thawing to break dormancy. Therefore, if planted late in the spring, these species will not germinate until the following year. Seeds that are planted too late in spring and germinate in early summer may be killed off by drought[4]. PennDOT Pub. 408 specifies that the crownvetch portion of Formula C can be seeded anytime except September and October.

This trial is an ongoing study and will require several years of monitoring to evaluate the versatility of Formula N relative to Formula C at the four seeding dates.

MANAGEMENT IMPLICATIONS

Recommendations cannot be made until the mixes are given at least three to four years to establish. However, it is apparent that either a more aggressive intermediate cover species is required and/or the seeding rates of Virginia wildrye must be increased in order to provide sufficient cover for erosion control. In critical areas, WSG plantings may require additional stabilization practices and temporary erosion and sediment control during establishment.

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[3]Pennsylvania Department of Environmental Protection. 2000. Erosion and Sediment Pollution Control Program Manual. Doc # 363-2134-008. 180 pp.

[4]USDA NRCS. 2002. Crownvetch Plant Fact Sheet. http://plants.usda.gov/factsheet/pdf/fs_cova2.pdf. 2 pp.

[5]USDA NRCS. 2006. Warm-Season Grasses in Pennsylvania. http://www.pa.nrcs.usda.gov. 4 pp.

[6]Miller C.F. and J.A. Dickerson. 1999. The Use of Native Warm Season Grasses for Critical Area Stabilization. Proc. of the 2nd Annual Eastern Native Grass Symposium, pp. 222-228.

Table 1. Formula C seed mix per PennDOT Pub. 408, Section 804 – Seeding and Soil Supplements.

Scientific Name	Common Name	Seeding Rate	
		lb/ac	lb/1000 S.Y.
Coronilla varia	crownvetch	19.4	4.0
Lolium multiflorum	annual ryegrass	24.2	5.0

Table 2. Formula N seed mix. PLS = pure live seed (%) = % germination x % purity / 100.

Scientific Name	Common Name	Seeding Rate (PLS)	
		lb/ac	lb/1000 S.Y.
Avena sativa	spring oats	30	6.0
Elymus virginicus	Virginia wildrye	10	2.0
Andropogon gerardii	big bluestem	6	1.2
Schizachyrium scoparium	little bluestem	6	1.2
Sorghastrum nutans	Indiangrass	6	1.2
Panicum virgatum	switchgrass	2	0.4
Desmodium canadense	showy tick-trefoil	2	0.4
Chamaecrista fasciculata	partridge pea	2	0.4

Table 3. Visual estimates of cover for Virginia wildrye and crownvetch, as well as presence of warm-season grass (WSG) seedlings as evaluated August 18, 2010, according to seed formula and timing. All seeding occurred in 2009. Each value is the mean of three replications, except the April timing of Formula C, which is the mean of two replications; one replication was excluded as an outlier. Differences between means were considered statistically significant at $p \leq 0.05$. Because a single LSD value could not be reported for crownvetch cover due to unequal replication, treatments means followed by the same letter are not significantly different. '+' = apparent, '-' = not apparent, na = not applicable.

Seed Formula	Timing	Date	Virginia wildrye	Crownvetch	WSG seedlings
			-------- % Cover --------		
N	1	13-Feb	12	1	+
N	2	23-Apr	18	3	+
N	3	7-Jul	2	3	-
N	4	21-Aug	0	1	-
C	1	13-Feb	na	17 a	na
C	2	23-Apr	na	96 b	na
C	3	7-Jul	na	4 c	na
C	4	21-Aug	na	3 c	na
LSD ($p \leq 0.05$)			4	---	---

ROADSIDES FOR WILDLIFE

Herbicide trade and common names: Glyflo, RoundupPro Dry (*glyphosate*), Garlon 4 (*triclopyr*), Plateau (*imazapic*).

Plant common and scientific names: big bluestem (*Andropogon gerardii*), black eyed susan (*Rudbeckia hirta*), Canada thistle (*Cirsium arvense*), common teasel (*Dipsacus fullonum*), creeping red fescue (*Festuca rubra* ssp. rubra), crownvetch (*Coronilla varia*), giant foxtail (*Setaria faberi*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), ox-eye sunflower (*Heliopsis helianthoides*), purple loosestrife (*Lythrum salicaria*), quackgrass (*Elytrigia repens*), round-headed bush clover (*Lespedeza capitata*), showy tick trefoil (*Desmodium canadense*), switchgrass (*Panicum virgatum*), tall fescue (*Festuca arundinacea*), wild bergamot (*Monarda fistulosa*).

INTRODUCTION

A five acre native planting was established as a pilot project to enhance wildlife habitat along roadsides through the cooperative efforts of PennDOT, Penn State Roadside Vegetation Management, and the PA Game Commission (PGC)[1]. The purpose of the project was to create habitat for small mammals and insects, encourage native song bird nesting while providing limited cover and food sources for whitetail deer. With these objectives in mind, native warm-season grasses were planted. Native warm-season grasses can reach a mature height of over four ft, limiting their use to areas beyond the safety clear zone of the roadway, which extends approximately 30 ft away from the pavement edge. In Pennsylvania, warm-season native grasses are a potential substitute for crownvetch because they can tolerate low fertility and low pH. Benefits include reduction of drifting snow, limitation of weed growth through competition, and minimal maintenance requirements. In addition, cutting or burning every couple of years, where permissible, eliminates brush encroachment. Cutting should be employed after July 15, at a minimum height of nine inches, to control brush and allow time for ground-nesting birds to hatch and fledge their young.

The project planting was observed ten years after establishment, and the apparent successes and challenges, as well as the preparation and maintenance activities to date, are detailed.

SITE PREPARATION AND MAINTENANCE

The demonstration site was located within the Cross Keys interchange of SR22 east and SR764, near Duncansville, PA. Prior to planting, the existing vegetation included many undesirable species (e.g. common teasel, Canada thistle, and quackgrass) that were encroaching on the established tall fescue and creeping red fescue stand. Crownvetch was also found throughout the site. While it is often planted on roadsides, it is a troublesome plant in a desirable grass community. Wet site conditions and minimal maintenance, both mowing and lack of herbicide treatments, favored the development of this undesirable plant community.

PennDOT contractors treated the site with *glyphosate* in the fall of 1999 to eliminate existing vegetation. On May 12, 2000, the area was retreated by Penn State Roadside Research Project personnel to address areas missed and prevent annual weeds, like giant foxtail, from becoming established. A tank mix of either 4 qts/ac Glyflo, 1 qt/ac Garlon 4, and 4 oz/ac Plateau or 72

[1] Mixon, K. 2000. Roadsides for Wildlife. Pennsylvania Game News. April 2000. Pages 15-17.

oz/ac Roundup Pro Dry, 1 qt/ac Garlon 4, and 3 oz/ac Plateau was applied at 5 gal/ac using Thinvert. The application was made using a Radiarc with a horizontally oriented spray pattern. The site was seeded in mid-May 2000 by Pennsylvania Game Commission personnel using a tractor-mounted Truax Flex 88 no-till drill. A mixture of wildflowers and little bluestem was seeded along the periphery of the area with taller, warm-season grasses seeded in the interior (Table 1). On June 8, 2001, the entire area was treated with Plateau at 6 oz/ac, a selective herbicide, to control emerging weeds using the horizontally oriented Radiarc pattern. A total of 26 gallons of mix (18.5 gallons of Thinvert solution and 7.5 gallons of aqueous solution including Sun It II methylated seed oil at a 5 percent, v/v rate) was applied at a targeted rate of 5 gal/ac.

OBSERVATIONS

The project planting was observed ten years after establishment. One of the short-term problems with seeding warm-season native grasses is their slow establishment rate. Despite generally slow establishment and the limited weed control during the fall 1999, the grasses provided respectable cover on the site by 2010. Observed at the site were naturally occurring forbs, like goldenrod, as well as some undesirable plants (e.g. common teasel, Canada thistle, and purple loosestrife). The continued persistence of crownvetch at the site is a concern; however, it has not required control measures at this time. Preliminary observations suggest birds, insects, and small mammals are utilizing the habitat.

CONCLUSION AND MANAGEMENT IMPLICATIONS

This pilot project demonstrates that warm-season grasses can be used and established with minimum maintenance. The height of the vegetation and desirability for nesting birds necessitate placement a safe distance from the roadway. Although this demonstration was established in a previously vegetated area, the mix of warm-season grasses is best utilized on newly constructed sites. The site must be regularly monitored to determine maintenance requirements. Brush and noxious weed species should be eliminated to reduce potential for reinfestation. Wildlife biologists will be required to monitor faunal activity and verify the overall habitat value of this project.

Table 1: Listing of the native species seeded to the five-acre pilot project (near Duncansville, PA) in mid-May 2000.

common name	scientific name	rate
Interior		(lbs PLS*/ac)
big bluestem	*Andropogon gerardii*	3-4
Indiangrass	*Sorghastrum nutans*	3-4
switchgrass	*Panicum virgatum*	3-4
Periphery		
little bluestem	*Schizachyrium scoparium*	3-4
black eyed susan	*Rudbeckia hirta*	0.5
ox-eye sunflower	*Heliopsis helianthoides*	0.25
wild bergamot	*Mondara fistulosa*	0.25
showy tick trefoil	*Desmodium canadense*	0.5
round-headed bush clover	*Lespedeza capitata*	0.25

* PLS = pure live seed.

SUMMARY OF OBSERVATIONS ON AN ESTABLISHED LIVING SNOW FENCE

Plant common and scientific names: Austree willow (*Salix matsudana x alba*), burning bush (*Euonymus alatus*), American arborvitae (*Thuja occidentalis*), Norway spruce (*Picea abies*), 'Streamco' willow (*Salix purpurea*), switchgrass (*Panicum virgatum*).

INTRODUCTION

Blowing and drifting snow create hazardous travel conditions on roads and ramps. Living snow fences are a sustainable, economical, and aesthetically pleasing alternative to traditional snow fence to reduce drifting snow and minimize the cost of winter maintenance. Living snow fences are composed of trees, shrubs, and/or grasses strategically placed and properly oriented to trap snow before it reaches the roadway. Several states, including Wyoming, Minnesota, New York, and Pennsylvania, have utilized living snow fences. This report describes the planting of a living snow fence in Gallitzin, PA along the exit-ramp from SR 22 east onto SR 4001 (Tunnel Hill St) in 1998. The planting was designed to reduce drifting snow and winter maintenance requirements on the windy, high elevation site.

MATERIALS AND METHODS

Switchgrass was planted in spring 1998 to an area 1.3 acres in size. One year later in spring 1999, four rows of trees and shrubs were planted. The rows, in sequence from the switchgrass planting toward the ramp, included 68 burning bush, 29 American arborvitae, 28 Norway spruce, and approximately 29 Austree willow. The burning bush was planted 5 ft on centers while the remaining species were planted in an offset pattern (i.e., 10 ft on centers) in relation to the burning bush to fill the gaps. The planting was watered manually during 1999 and later supplemented by a product called "DriWater"[1]. This product contains water bound by gums and resins within tubes placed in the soil around the newly planted tree or shrub. Over time, microorganisms break down the gums and resins and slowly release water for the plants.

The entire row of burning bush died during the winter of 2003-2004 and was replaced on May 12, 2004 with 150 'Streamco' willow. The willows were one-year old bare root stock planted 3 ft on centers. In April 2008, about half of the willows were cut back to approximately 8 inches in height.

OBSERVATIONS

PennDOT personnel observed some wind damage on trees and shrubs following the winter of 1999. By 2000, the switchgrass stand was developing. The trees and shrubs established except for Austree willow. Little snowfall was reported during the winter of 2000; however, local PennDOT crews reported that the plants trapped the snow that blew on site. The switchgrass continued to fill in during the 2001 season, but wind damage occurred to the burning bush and arborvitae. Similar winter conditions existed in 2001 and, again, local PennDOT maintenance crews observed comparable snow trapping performance from the planting. No observations beyond the first three winters after planting were recorded.

[1] DriWater Time Release Water (DriWater, Inc., Santa Rosa, CA)

By 2010, the switchgrass stand was largely absent. There were a few scattered switchgrass plants within the original planting area that had been maintained as a meadow through mowing. It is impossible to say why the switchgrass did not thrive at this location. Some plausible factors include: competition from other species present at the site, including goldenrod, or mowing at the improper height, timing, or frequency. The 'Streamco' willow had established well with noticeable height differences due to an April 2008 mowing of a portion of the stand. The cutting was performed to remove unwanted vegetation, eliminate dead wood, and invigorate the willow shrubs. This resulted in a shorter, denser shrub in the cut section of the row. The arborvitae had observable foliar damage that resembled repeated winter desiccation injury; however, the plants remained viable and generally healthy. The Norway spruce was healthy and thriving. Both burning bush and Austree willow were completely absent from the site.

CONCLUSIONS

Proper plant selection is paramount for a successful living snow fence. The open terrain and often, marginal soils create a harsh environment. Burning bush and Austree willow were not suitable plant materials at Gallitzin. However, Arborvitae, Norway spruce, and 'Streamco' willow were better choices. In addition, it is important to confirm that the height and density of the chosen plants will work for each design. Height and density of the plants will determine the amount of snow that can be stored and the setback needed for the planting to allow for snow accumulation on the leeward side of the barrier without falling onto the roadway[2].

Switchgrass, similar to other warm-season species, takes several years to establish, especially in poor soils. Many factors can inhibit growth. A site with low quality soil having extreme bulk density; properties that restrict root growth, such as hard pans or fill material; poor drainage; or improper pH or fertility levels can deter the growth of plants. Soil tests should be taken prior to planting to assess the soil condition and need for amendments, like fertilizer or lime. Extremely poor soils may require modification with compost or the addition and incorporation of several inches of topsoil to the planting area. Additionally, weed control plus proper planting depth (approximately one-quarter to one-half in) and timing (ideally, April 1 through June 15) are necessary to ensure the successful establishment.

MANAGEMENT IMPLICATIONS

A living snow fence is not practical for all situations. First, the area must be large enough to accommodate the projected mature plant size and relative snow drop zone created by the plants used[2]. Soil conditions may also preclude using live plant material without significant modifications to the site, making the whole job cost prohibitive. With adequate site conditions, living snow fences provide a viable option to reduce the amount of snow on the roadway while providing an aesthetically appealing and low maintenance ornamental planting.

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[2] Josiah S. and Majeski M. 2002. Living Snow Fences. University of Minnesota. http://www.extension.umn.edu/distribution/naturalresources/DD7277.html