Roadside Vegetation Management Research – 2013 Report

ANNUAL REPORT

June 30, 2013

By Jon M. Johnson, David A. Despot, and James C. Sellmer

THE PENNSYLVANIA STATE UNIVERSITY

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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: Investigating Herbicide Tank Mixes for Control of Morrow's Honeysuckle (*Lonicera morrow*ii), Evaluation of Oil-Soluble Aminocyclopyrachlor for Use as a Cut Stump Treatment, Evaluation of Oil-Soluble Aminocyclopyrachlor for Use as a Basal Bark Treatment, Comparison of Herbicide and Mowing Regimes for Control of Canada Thistle in a Grass Groundcover – Third Year Results, Conversion of Canada Thistle Infested Crownvetch Groundcover to Fine Fescue Turf – Details of Trial Establishment, Evaluation of Aminocyclopyrachlor Combinations for Spring Applied Broadleaf Treatments in Turf, Evaluation of Aminocyclopyrachlor Combinations for Summer Applied Broadleaf Treatments in Turf, Evaluation of Turf Phytotoxicity Caused by Escort XP, Krenite S, and MAT28, Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Four, Evaluation of Indaziflam, Pendimethalin, and Prodiamine in Tank Mixes for Bareground Weed Control, Options for Postemergence Kochia and Marestail Control.

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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 2012 season: E.I. DuPont de Nemours & Co. and Bayer Environmental Science.

This work was sponsored by the Pennsylvania Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration, U.S. Department of Transportation, or the Commonwealth of Pennsylvania at the time of publication. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

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 that 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

Report # PA-2011-006-PSU RVM Roadside Vegetation Management Research – 2011 Report

Report # PA-2012-007-PSU RVM Roadside Vegetation Management Research – 2012 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 statistical analysis, particularly techniques involved in the analysis of variance. The use of these techniques allows for the establishment of criteria for significance. Numbers are said to be significantly different when the differences between them are most likely due to the different treatments, rather than 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. Once this level of certainty is reached with the analysis of variance, Tukey's HSD separation test is employed to separate the treatments into groups that are significantly different from each other. In many of our results tables, there is/are a letter or series of letters following each number and a notation which states, 'within each column, numbers followed by the same letter are not significantly different at the 0.05 level'. In addition, absence of letters within a column or the notation 'n.s.' indicates that the numbers in that column are not significantly different from each other at the 0.05 level.

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. DF = dry flowable, EC=emulsifiable concentrate, F = flowable liquid, L = liquid, ME=microencapsulated, OL=oil soluble, RTU = ready to use, S=water soluble, SC = soluble concentrate, SL = soluble liquid, WDG=water-dispersible granules.

Trade Name	Active Ingredients	Formulation	Manufacturer
Aquasweep	2,4-D + triclopyr	34.2 + 15.2 S	Nufarm Specialty Products
Arsenal	imazapyr	2 S	BASF Specialty Products
Diuron 80	diuron	80 WDG	Drexel Chemical Company
DMA 4 IVM	2,4-D	3.8 S	Dow AgroSciences LLC
Escort XP	metsulfuron methyl	60 WDG	E.I. DuPont de Nemours & Co.
Esplanade	indaziflam	200 SC	Bayer Environmental Science
Frequency	topramezone	2.8 S	BASF Specialty Products
Garlon 3A	triclopyr amine	3 S	Dow AgroSciences LLC
Garlon 4	triclopyr ester	4 EC	Dow AgroSciences LLC
Krenite S	fosamine	4 S	E.I. DuPont de Nemours & Co.
MAT28	aminocyclopyrachlor	50 WDG	E.I. DuPont de Nemours & Co.
MAT28 OL	aminocyclopyrachlor	1 OL	E.I. DuPont de Nemours & Co.
MAT 240SL	aminocyclopyrachlor	2 SL	E.I. DuPont de Nemours & Co.
Matrix	rimsulfuron	25 WDG	E.I. DuPont de Nemours & Co.
Milestone VM	aminopyralid	2 S	Dow AgroSciences LLC
Millenium Ultra	2,4-D + clopyralid + dicamba	37.32+2.54+4.65 S	NuFarm Americas, Inc.
MSM	metsulfuron methyl	1.25 L	E.I. DuPont de Nemours & Co.
Opensight	aminopyralid + metsulfuron	62.13 + 9.45 WDG	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
Panoramic	imazapic	2 SL	Alligare LLC
Pathfinder II	triclopyr ester	13.6 RTU	Dow AgroSciences LLC
PennDOT Custom Blend (or Custom Blend)	aminocyclopyrachlor + metsulfuron	47.9 + 2.5 DF	E.I. DuPont de Nemours & Co.
Pendulum Aquacap	pendimethalin	3.8 ME	BASF Specialty Products
Perspective	aminocyclopyrachlor + chlorsulfuron	39.5 + 15.8 DF	E.I. DuPont de Nemours & Co.
Plateau	imazapic	2 S	BASF Specialty Products
Proclipse	prodiamine	65 WDG	Nufarm Specialty Products
Roundup Pro Concentrate	glyphosate	5 S	Monsanto Company
Roundup Power Max	glyphosate	5.5 S	Monsanto Company
Streamline	aminocyclopyrachlor + metsulfuron	39.5 + 12.6 DF	E.I. DuPont de Nemours & Co.
Telar XP	chlorsulfuron	75 WDG	E.I. DuPont de Nemours & Co.
Three Way	2,4-D + mecoprop-p dicamba	30.56 + 8.17 + 2.77 S	Lesco, Inc.
Transline	clopyralid	3 S	Dow AgroSciences LLC
Triplet LO	2,4-D + mecoprop-p + dicamba	47.3 + 8.2 + 2.3 S	NuFarm Americas, Inc.
Vanquish	dicamba-glycolamine	4 S	Syngenta Crop Protection LLC
Velpar DF	hexazinone	75 WDG	E.I. DuPont de Nemours & Co.
Vista	fluroxypyr	1.5 EC	Dow AgroSciences LLC

INVESTIGATING HERBICIDE TANK MIXES FOR CONTROL OF MORROW'S HONEYSUCKLE (LONICERA MORROWII)

Herbicide trade and common names: Aquasweep (*2,4-D + triclopyr*); Escort XP (*metsulfuron*); Garlon 3A (*triclopyr* amine); Roundup Pro Concentrate (*3.7 lb ae glyphosate/gal*); MAT28 (*aminocyclopyrachlor*); Milestone VM (*aminopyralid*); Opensight (*aminopyralid + metsulfuron*); PennDOT Blend, Streamline (*aminocyclopyrachlor + metsulfuron*); 2,4-D (*2,4-D*); Vanquish (*dicamba*).

Plant common and scientific names: amur honeysuckle (*Lonicera maackii*), Morrow's honeysuckle (*Lonicera morrowii*), tatarian honeysuckle (*Lonicera tatarica*).

ABSTRACT

Exotic shrub honeysuckle, including Morrow's honeysuckle, has become more prevalent along Pennsylvania's roads with the repeated use of similar herbicide tank mixes within PennDOT's brush control program. The herbicide 'glyphosate' has demonstrated effectiveness using foliar applications but is non-selective and damaging to the understory. A tank mix that is both effective at controlling Morrow's honeysuckle and safe to grasses would be an ideal complement to the current weed and brush program. Both newer (aminocyclopyrachlor and aminopyralid) and older (2,4-D) chemistry may offer a potential solution to this problem. This experiment investigated ten herbicide tank mixes utilizing the previously mentioned active ingredients for control of this species and the impact to the understory. Preliminary data collected 30 days after treatment, DAT, showed injury symptoms on Morrow's honeysuckle and understory. It is apparent that herbicide mixes containing glyphosate or 2,4-D resulted in the most significant initial injury to the Morrow's honeysuckle with a rating of 94 to 96 percent injury. Data collected next season should offer insight on the long-term efficacy of the treatments. All treatments caused some injury to both the grass and forb understory. Tank mixes that included 8 oz/ac PennDOT Blend or 4 oz/ac PennDOT Blend with 0.5 oz/ac Escort XP and glyphosate combinations proved to have a significant impact on the grass understory compared to other treatments tested while the forbs were equally damaged by all of the treatments.

INTRODUCTION

Exotic shrub honeysuckles are introduced woody plants that have become widespread along Pennsylvania's roads. The most common species within this region of the U.S. include tatarian, Morrow's, and amur honeysuckle. These plants are difficult to control with the herbicide tank mixes and rates commonly utilized by PennDOT and their contractors for brush control treatments, resulting in an expansion of existing stands along many corridors. Glyphosate has demonstrated effectiveness on controlling exotic shrub honeysuckle but is non-selective and harms the grass understory. Selective chemistry that controls exotic shrub honeysuckle but does not injure grasses would be ideal. Newer chemistry such as aminocyclopyrachlor (ACP) and aminopyralid has shown effectiveness on a host of woody species and are selective to grasses. [1,2,3] The active ingredient aminocyclopyrachlor is available in several premix combinations. Two

[1] Johnson et al. 2010. Response of Black Locust to Foliar Applications of Aminocyclopyrachlor. Roadside Vegetation Management Research – 2010 Report. pp. 4-5.

forms were tested in this experiment including the PennDOT Blend and Streamline containing aminocyclopyrachlor (MAT28) and metsulfuron (Escort XP) at different ratios. An 8 oz rate of the PennDOT Blend equates to 7.67 oz of MAT28 (50% ACP) and 0.33 oz Escort XP while 2.5 oz Streamline is equivalent to 1.97 oz MAT28 (50% ACP) and 0.52 oz Escort XP. In addition, an older chemistry, 2,4-D, which showed promise in a 2011 demonstration on controlling shrub honeysuckle was included. This experiment was designed to determine and compare the efficacy of these products in combination with other broadleaf selective herbicides for foliar applied control of Morrow's honeysuckle.

MATERIALS AND METHODS

The experiment was established in close proximity to the interchange of I-99 and I-80 near Bellefonte, PA. Ten herbicide treatments were tested including: 8 oz/ac PennDOT Blend; 8 oz/ac PennDOT Blend plus 0.25 oz/ac Escort XP; 64 oz/ac Garlon 3A plus 4 oz/ac PennDOT Blend and 0.5 oz/ac Escort XP; 64 oz/ac Garlon 3A plus 2.5 oz/ac Streamline; 64 oz/ac Garlon 3A plus 3.3 oz/ac Opensight; 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 104 oz/ac Roundup Pro Concentrate[4]; 32 oz/ac Garlon 3A plus 32 oz/ac Vanquish and 7 oz/ac Milestone VM; 104 oz/ac Roundup Pro Concentrate alone; 96 oz/ac Aquasweep plus 0.5 oz/ac Escort XP; and an untreated check. All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v. Plots 10 by 25 feet in size were arranged in a randomized complete block design with four replications. Herbicides were applied at 50 gal/ac on July 10, 2012, using a CO_2 powered backpack sprayer equipped with a GunJet spray gun and single Boomjet XP 20L nozzle.

Percent injury (0 = no injury, 100 = complete necrosis) to Morrow's honeysuckle and the grass and forb understory was evaluated on August 9, 2012, 30 days after treatment, 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 Tukey's HSD separation test.

RESULTS AND DISCUSSION

Injury to Morrow's honeysuckle ranged from 29 to 96 percent for the herbicide treatments. Treatments containing 2,4-D or Roundup Pro Concentrate resulted in significant injury with rating values from 94 to 96 percent. These treatments included Garlon 3A plus 2,4-D or Roundup Pro Conc.; Roundup Pro Conc. alone; and Aquasweep plus Escort XP. All other treatments included either aminocyclopyrachlor (PennDOT Blend or Streamline) or aminopyralid (Milestone VM or Opensight) in combination with other herbicides and resulted in injury values of 29 to 54 percent. The most dramatic injury to grasses occurred with combinations containing the PennDOT Blend or Roundup Pro Conc. and varied from 54 to 100 percent. Garlon 3A plus 2,4-D or Streamline provided moderate injury to grasses at 50 and 52 percent and were statistically different than either the untreated check (0 percent) or Roundup

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[2] Johnson et al. 2009. Response of Black Locust, Red Oak, and Tulip Poplar to Foliar Applications of DPX-KJM44. Roadside Vegetation Management Research – 2009 Report. pp. 11-13.

[3] Johnson et al. 2009. Grass-safe Herbicide Mixes for Woody Vegetation Control. Roadside Vegetation Management Research – 2009 Report. pp. 6-10.

[4] Roundup Pro Concentrate (3.7 lb ae glyphosate/gal), Monsanto Co., St. Louis, MO. 104 oz Roundup Pro Concentrate contains the equivalent amount of glyphosate acid as found in 128 oz Roundup Pro.

Pro Conc. alone (100 percent). Treatments that included Garlon 3A and aminopyralid (Milestone VM or Opensight) or Aquasweep plus Escort XP caused the least injury to grasses from 19 to 46 percent. All treatments caused similar injury to the forb understory and ranged from 62 to 99 percent.

CONCLUSIONS

Some chemistry more swiftly displays symptoms while other herbicides act slower within the plant. So, the initial injury values do not provide conclusive evidence that any treatment provided long-term control of Morrow's honeysuckle. Even those treatments that resulted in high percent injury rates in the canopy injury may develop new foliage in the upcoming season. Evaluations made at one year after treatment, will better determine whether any treatment provided complete and lasting control.

The understory damage does demonstrate that tank mixes that include 8 oz/ac PennDOT Blend or 4 oz/ac PennDOT Blend with 0.5 oz/ac Escort XP and treatments containing Roundup Pro Conc. have a significant impact on the grass understory. Forbs that were over sprayed were equally damaged by all of the treatments.

MANAGEMENT IMPLICATIONS

It is too early to suggest operational use of any of the treatments tested for control of Morrow's honeysuckle. Next season's evaluation will provide insight on which herbicide mixes performed best over the long term. However, all mixes and use rates used in this experiment resulted in injury to both the grass and forb understory.

Table 1: Percent injury to morrow's honeysuckle (*Lonicera morrowii*, LONMO) plus the grass and forb understory. The trial was visually rated for percent injury on August 9, 2012 (30 days after treatment, DAT). Treatments were applied on July 10, 2012. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Percent Injury		
Product	Rate	LONMO	Grasses	Forbs
	(oz/ac)			
Untreated	---	0 a	0 a	0 a
PennDOT Blend	8	29 b	54 b-e	67 b
PennDOT Blend Escort XP	8 0.25	42 b	87 cde	95 b
Garlon 3A PennDOT Blend Escort XP	64 4 0.5	50 b	67 cde	84 b
Garlon 3A Vanquish Milestone VM	32 32 7	54 b	44 abc	62 b
Garlon 3A Streamline	64 2.5	42 b	52 bcd	84 b
Garlon 3A Opensight	64 3.3	49 b	46 abc	80 b
Garlon 3A 2,4-D	64 64	94 c	50 bc	86 b
Garlon 3A Roundup Pro Conc.	64 104	95 c	97 de	99 b
Roundup Pro Conc.	104	95 c	100 e	99 b
Aquasweep Escort XP	96 0.5	96 c	19 ab	67 b

EVALUATION OF OIL-SOLUBLE AMINOCYCLOPYRACHLOR FOR USE AS A CUT STUMP TREATMENT

Herbicide trade and common names: Garlon 4 (*triclopyr* ester), MAT28 OL (1 lb *aminocyclopyrachlor*/gal, oil soluble formulation)
Plant common and scientific names: boxelder (*Acer negundo*), red maple (*Acer rubrum*), and red oak (*Quercus rubra*)

ABSTRACT

Hardwood cut stump sprout control is a priority among vegetation managers to reduce the return of unwanted brush along the right-of-way. Herbicide treatments are the primary control method for resprouting of cut stumps. In June 2011, a varying rate herbicide experiment was initiated along Interstate 80 in central Pennsylvania to test the efficacy of an experimental oil soluble formulation of aminocyclopyrachlor (MAT28 OL) designed specifically for cut stump applications. Treatments included MAT28 OL alone at 0.5, 1, 2, 4 and 8% v/v and Garlon 4 alone at 20% v/v mixed in basal oil as a positive control standard and cutting only as a negative control. The three species in the trial included red oak, red maple, and boxelder. At approximately 1 year after treatment, MAT28 resulted in 70 to 80% mortality (the complete absence of stump sprouts) on red oak and 100% mortality on boxelder when applied at a rate of 1% v/v and above. Complete control of red maple stumps occurred only at rates of 4% v/v or greater. Garlon 4 at 20% v/v caused 100% mortality to all three species tested.

INTRODUCTION

Hardwood trees tend to re-sprout quickly following cutting because of the stored energy in the existing root system and loss of hormonal control allowing the activation of dormant epicormic buds. Re-sprouting is a survival mechanism as cut trees attempt to restore leaf surface and the associated sugar production derived from photosynthesis. Re-sprouting is a concern for vegetation managers because right-of-way areas that have been cleared of unwanted woody vegetation can rapidly become overgrown with sprouts from existing stumps and accompanying root systems. The surfaces of stumps are typically treated with herbicides after cutting in an effort to reduce sprouting.

An experimental formulation of the active ingredient *aminocyclopyrachlor* designed for oil-based applications (MAT28 OL) has previously been tested for cut stump treatments. MAT28 OL at rates as low as 5% v/v mixed in basal oil prevented sprouting on black locust, scrub oak, and sugar maple stumps.[1] In June 2011, a rate experiment was initiated along Interstate 80 in central Pennsylvania to test the range of efficacy of MAT28 OL.

MATERIALS AND METHODS

The experiment was conducted along Interstate 80 in Clearfield and Centre counties. The red oak and red maple sites were located in Clearfield County just east of the Woodland exit, while the boxelder site was established in Centre County between the Lamar and Bellefonte exits.

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[1] Johnson, J.M. et al 2011. Evaluation of Aminocyclopyrachlor for Use in Cut Stump Applications. Roadside Vegetation Management Research - 2011 Report, pp. 1-2.

Treatments were applied to the remaining stumps of trees immediately following cutting on June 28, 29, and 30, 2011 for red oak, red maple, and boxelder, respectively. The trial was a completely randomized design with ten stems per treatment and each stem serving as a replicate. Stem diameter for the species (max, min, average) were as follows, reported in inches: boxelder 2.4, 0.5, 0.9; red oak 3.6, 0.5, 1.4; and red maple 3.4, 0.5, 1.8. Treatments were applied with a foam paint brush to only the cut surface of the stump. The seven treatments included MAT28 OL alone at 0.5, 1, 2, 4, and 8% v/v; Garlon 4 alone at 20% v/v; and an untreated check (cut only). All treatments were mixed in Arborchem Low Odor Basal Oil.

Red oak and red maple were evaluated for the presence of sprouts on July 28 and October 3, 2011 plus May 10 and July 25, 2012 which corresponded to 30, 97, 317, and 393 days after treatment, DAT, for red oak and 29, 96, 316, and 392 DAT for red maple. Boxelder targets were evaluated for the presence of sprouts on July 27 and October 3, 2011 and May 10 and July 19, 2012 which corresponds to 27, 95, 315, and 385 DAT.

RESULTS AND DISCUSSION

There were a few notable differences in mortality, (i.e., the complete absence of stump sprouts) among the treatments tested on the three species. Red oak did not re-sprout immediately and at 30 days after treatment, DAT, all herbicide treatments provided 100% mortality (Table 1). However, at 393 DAT 0.5% v/v MAT28 resulted in 30% mortality, 1 to 4% v/v MAT28 produced 70% mortality, and 8% v/v MAT28 80% mortality. Twenty-percent v/v Garlon 4, the positive standard control prevented all stumps from producing sprouts, while all untreated stumps re-sprouted. Red maple produced sprouts on a single stump treated with 0.5% v/v MAT28 and one at 2% v/v MAT28; however, the 90% mortality was not significantly different from complete mortality observed with all other herbicide treatments at 29 DAT (Table 2). At 392 DAT rates of 0.5 and 1% v/v MAT28 resulted in 10 and 40% mortality on red maple and were not significantly different than the cutting only negative control treatment with 10% mortality. Rates of 2% v/v MAT28 resulted in an increase in mortality of 60% and rates of 4% v/v or greater yielded 100% mortality on red maple. All boxelder stumps treated with herbicide produced significant mortality from 90 to 100% at 27 and 385 DAT, respectively compared to the cut only treatment with 40% mortality (Table 3).

CONCLUSIONS

Both species and herbicide rate appear to be important factors in the effectiveness of MAT28 OL at preventing stump sprouts. The biology of oak lends itself to survival after disturbance. In forestry, oak is considered a fire tolerant species because of the large energy reserves stored in the root system that enable it to recover from disturbance such as fire or cutting.[2] Red maple and boxelder do not develop the extensive root system early in their life and are less adapted to recover following disturbance.

Control may also be impacted by the method of application and dosage. Complete control was observed in previous tests on black locust, scrub oak, and sugar maple with rates of MAT28 OL as low as 5% v/v; however, the application was made beyond the cut surface and included the sides of the stump to the soil line. In this experiment, only the cut surface was treated. These

[2] Burton Barnes, et al., Forest Ecology, 4th Edition, (New York: John Wiley and Sons, 1998) 287.

factors may account for some of the differences in effectiveness across the species and dosages tested. It is apparent that rates of MAT28 OL at 5% v/v or greater offer nearly complete control of sprouts on a range of species using the cut surface method.

MANAGEMENT IMPLICATIONS

The MAT28 OL formulation is not currently labeled for use as a cut stump application. If this formulation were to become available, it may be useful as an alternative chemical to retard the growth of sprouts from cut stumps. Cost and safety would need to be compared with Garlon 4, which was quite effective in this experiment. More testing of MAT28 OL on different species and under a wider variety of conditions would be prudent. Also, the potential for damage by MAT28 OL to non-target vegetation has been demonstrated in other trials and should be further evaluated.

Table 1. Percent mortality on red oak at the Clearfield County, I-80 trial site near Woodland, PA treated with varying rates of MAT28 OL, Garlon 4, and a no herbicide treatment control. Trees were cut and treatments were applied to the stumps on June 28, 2011. Stumps were evaluated for sprouts on July 28, 2011 (30 DAT) and July 25, 2012 (393 DAT). Column means followed by the same letter are not significantly different at p≤0.05.

Treatment	% Mortality July 2011 30 DAT	% Mortality July 2012 393 DAT
Cut +MAT28 OL 0.5% v/v	100 b	30 ab
Cut + MAT28 OL 1% v/v	100 b	70 bc
Cut + MAT28 OL 2% v/v	100 b	70 bc
Cut + MAT28 OL 4% v/v	100 b	70 bc
Cut + MAT28 OL 8% v/v	100 b	80 bc
Cut + Garlon 4 20% v/v	100 b	100c
Cut only	70 a	0 a

Table 2. Percent mortality on red maple at the Clearfield County, I-80 trial site near Woodland, PA treated with varying rates of MAT28 OL, Garlon 4, and a no herbicide treatment control. Trees were cut and treatments were applied to the stumps on June 29, 2011. Stumps were evaluated for sprouts on July 28, 2011 (29 DAT) and July 25, 2012 (392 DAT). Column means followed by the same letter are not significantly different at p≤0.05.

Treatment	% Mortality 7/28/2011 29 DAT	% Mortality 7/25/2012 392 DAT
Cut +MAT28 OL 0.5% v/v	90 a	10 a
Cut + MAT28 OL 1% v/v	100 a	40 ab
Cut + MAT28 OL 2% v/v	90 a	60 bc
Cut + MAT28 OL 4% v/v	100 a	100 c
Cut + MAT28 OL 8% v/v	100 a	100 c
Cut + Garlon 4 20% v/v	100 a	100 c
Cut only	70 a	10 a

Table 3. Percent mortality on boxelder at the Centre County, I-80 trial site near Bellefonte, PA treated with varying rates of MAT28 OL, Garlon 4, and a no herbicide treatment control. Trees were cut and treatments were applied to the stumps on June 30, 2011. Stumps were evaluated for sprouts on July 27, 2011 (27 DAT) and July 19, 2012 (385 DAT). Column means followed by the same letter are not significantly different at p≤0.05.

Treatment	% Mortality July, 2011 27 DAT	% Mortality July, 2012 385 DAT
MAT28 OL 0.5% v/v	90 b	90 b
MAT28 OL 1% v/v	100 b	100 b
MAT28 OL 2% v/v	100 b	100 b
MAT28 OL 4% v/v	100 b	100 b
MAT28 OL 8% v/v	100 b	100 b
Garlon 4 20% v/v	90 b	100 b
Cut Only	40 a	40 a

EVALUATION OF OIL-SOLUBLE AMINOCYCLOPYRACHLOR FOR USE AS A BASAL BARK TREATMENT

Herbicide trade and common names: Garlon 4, Pathfinder II (*triclopyr* ester); MAT28 OL (1 lb *aminocyclopyrachlor*/gal, oil soluble formulation).
Plant common and scientific names: black locust (*Robinia pseudoacacia*), sugar maple (*Acer saccharum*), and red oak (*Quercus rubra*).

ABSTRACT

As trees and shrubs mature, they can cause sight-distance and safety issues on the roadside right-of-way. The most cost-effective approach is to eliminate woody vegetation while the populations are still young and beginning to establish. Basal bark treatments are one option for controlling sparse populations of small caliper (i.e., less than 6 in. basal diameter), woody plants. The active ingredient, *triclopyr* ester, found in Garlon 4 or Pathfinder II has a proven track record and is the standard herbicide used for basal bark treatment. A newer active ingredient, *aminocyclopyrachlor*, has shown promise and is currently labeled and sold in premixes with other herbicides for controlling woody vegetation using foliar or ground applications. A formulation of *aminocyclopyrachlor* that is more miscible in oil has been developed for basal bark and cut surface treatments but is experimental and no products containing this active ingredient are currently labeled for this application. The efficacy of this 1 lb *aminocyclopyrachlor*/gal product (MAT28 OL) at 5, 10, 15, and 20% v/v was compared to Garlon 4 at 20% v/v on black locust, sugar maple, and red oak using basal bark treatments. Rates of 5% v/v MAT28 OL or greater provided control similar to the standard Garlon 4 treatment, except on black locust at approximately 1-year after treatment, YAT. Black locust required a minimum of 10% v/v MAT28 OL to achieve similar results. The mortality or percentage of completely defoliated black locust trees ranged from 70 to 100 percent at one YAT for trees treated with MAT OL at 10 to 20% v/v or Garlon 4. However, mortality varied from the control ratings, especially for red oak with 20 to 80% mortality in part due to treatment impact on the canopy (i.e., reduction of leaf area but not complete defoliation synonymous with tree mortality). These results are positive; however, evaluation at two years after treatment would provide valuable information on whether the lingering foliage was sufficient to allow for tree survival, especially at the lower rates of MAT28 OL used.

INTRODUCTION

Trees and brush on the right-of-way can create sight distance and safety hazards for the motoring public and the removal of these unwanted woody plants is a priority for vegetation managers. The most cost effective approach to keeping the right-of-way clear is to target these plants when they are small before they develop into large populations. Basal bark treatment offers one option for controlling sparse populations of smaller trees as the plants are beginning to establish. Garlon 4 and Pathfinder II RTU contain the active ingredient *triclopyr* and have been the herbicide of choice for this application. *Aminocyclopyrachlor* is a newer chemistry that has previously been tested for basal bark treatment on Russian olive and mesquite and provided 90 percent or greater control.[1,2] Compatibility issues were observed with the original formulations of *aminocyclopyrachlor* when diluting in basal oil.[3] Now an experimental formulation of the active ingredient *aminocyclopyrachlor*, MAT28 OL, is being investigated for this treatment method. This oil-soluble formulation contains 1 lb *aminocyclopyrachlor*/gal. This experiment will evaluate the efficacy of MAT28 OL at various rates on black locust, sugar maple, and red oak using the basal bark application method.

MATERIALS AND METHODS

The experiment consisted of six herbicide treatments including varying rates of MAT28 OL at 5, 10, 15, and 20% v/v; a positive standard control of Garlon 4 at 20% v/v; and an untreated check. All treatments were mixed in Arborchem Low Odor Basal Oil. The treatments were applied to the lower 12 to 18 inches of stem of three tree species (i.e., black locust, sugar maple, and red oak). The experiment was a completely randomized design with ten stems per treatment. Stem diameter ranges for the species (max, min, average) were as follows, reported in cm: black locust 11.9, 2.2, 6.5; sugar maple 8.2, 1.5, 3.9; and red oak 11.0, 1.1, 3.3. Black locust and sugar maple stands were located along SR1008 east of Bellwood, PA. The red oak was located on the N. Atherton exit ramp of I-99N in State College, PA. All stems were treated using a CO_2-powered sprayer equipped with an ultra low volume basal wand and adjustable conejet nozzle with Y-2 tip. All black locust, sugar maple, and red oak were treated on June 23, 2011.

Percent injury was evaluated for black locust on September 26, 2011, 95 days after treatment, DAT, and percent control on June 27, 2012, 370 DAT (Table 1). Percent injury was evaluated for sugar maple on September 26, 2011, 95 DAT, and percent control on July 25, 2012, 403 DAT (Table 2). Red oak was evaluated for percent injury on September 28, 2011, 97 DAT, and percent control on August 6, 2012, 415 DAT (Table 3). Percent injury was rated on a scale of 0 to 100 where "0" = no injury; "25' = some chlorosis and necrotic leaves; "50" = significant necrosis and/or defoliation; "75" = severe necrosis and/or defoliation; "90-100" = mostly necrotic and/or defoliated. Percent control is a measure of percent leaf loss in canopy compared to untreated and also reflected injury symptoms; mainly cupping and malformation of leaves where "0" = no loss of leaves or injury symptoms present; " 50" = one-half of canopy missing foliage and/or distinct signs of injury to existing foliage; "100" = complete defoliation. Percent mortality was derived by dividing the number of completely controlled stems by 10 (the number treated for each treatment) x 100 using the data collected in 2012 for each species and is shown in each table.

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[1] Lym, R. G. 2011. Evaluation of Aminocyclopyrachlor for Russian Olive Control. The 2011 Research Progress Report of the Western Society of Weed Science. pp. 18-19. http://www.wsweedscience.org/Research%20Report%20Archive/2011%20WSWS%20RPR.pdf

[2] Hart C. et al. 2011. Mesquite Basal Applications with Aminocyclopyrachlor. Texas AgriLIFE Extension Service Progress Report. pp.1-5. http://stephenville-tamu-edu.wpengine.netdna-cdn.com/files/2011/02/DuPont-Mesquite-Basal1.pdf

[3] 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.

RESULTS AND DISCUSSION

At 95 DAT, the initial injury to black locust ranged from 91 to 99 percent for 10 to 20% v/v MAT28 OL and was not significantly different than the 20% v/v Garlon 4 (100%) standard control. Control of black locust continued to be comparable to the complete control provided by 20% v/v Garlon 4 at 370 DAT and ranged from 76 to 100% for the 10 to 20% v/v MAT28 OL treatments. Percent mortality was 70, 90, and 100 for treatments containing 10, 15, and 20% v/v MAT28 OL, respectively, and 100% for the Garlon 4 treatment at this date. The lowest rate of 5% v/v MAT28 OL provided only moderate injury and control during the course of this trial and resulted in 60% injury (95 DAT), 49% control (370 DAT), and 30% mortality (370 DAT).

All rates of MAT28 OL provided injury and control similar to the Garlon 4 treatment when applied to sugar maple. Injury ranged from 88 to 100% and control from 94 to 100% at 95 and 403 DAT, respectively, for all rates of MAT28 OL tested while Garlon 4 offered 100% injury and control at those dates. All herbicide treatments resulted in 80 to 100% mortality at 403 DAT to sugar maple. Injury was observed on a few untreated sugar maple trees located within several feet of treated stems and resulted in injury and control values of 10 and 22%; however, none of the trees were completely defoliated as reflected by no mortality.

Red oak declined more slowly than the other species treated. At 97 DAT the injury for all MAT28 OL treatments was similar and ranged from 14 to 38% and was significantly different than Garlon 4 with 93% injury. However, by 415 DAT 5 to 20% v/v MAT28 OL treatments provided 74 to 98% control and were similar to Garlon 4 at 98% control. Though average control values were high for all MAT28 OL treatments, the percent mortality (stems completely defoliated) was only 20 to 40% for rates of 5 to 15% v/v MAT28 OL. Rates of 20% v/v MAT28 OL caused 80% mortality and approached the 90% mortality observed with the Garlon 4 treatment.

CONCLUSIONS

Rates of 5% v/v MAT28 OL or greater provided control similar to the standard Garlon 4 treatment, except on black locust. This species required a minimum of 10% v/v MAT28 OL to achieve similar results. The percent mortality sometimes varied from the control ratings, especially for red oak, because the treatments may have significantly impacted the canopy but not completely defoliated the tree. It would be prudent to evaluate all three species 2-years after treatment, YAT, to determine whether the lingering foliage was sufficient to allow survival of the trees, especially at the lower rates of MAT28 OL used.

MANAGEMENT IMPLICATIONS

Garlon 4 at 20% v/v remains an effective herbicide treatment for basal bark treatment on a host of species. Products that contain *aminocyclopyrachlor* are not currently labeled for basal bark application but continued investigation of experimental formulations, such as MAT28 OL, will help to determine suitability for control of trees commonly found on Pennsylvania's right-of-ways. There is some cause for concern because the MAT28 OL caused damage to nearby untreated trees. If labeled for this treatment method, the lowest use rates that still offer control would be the most desirable for both safety and cost.

Table 1. Percent injury, control, and mortality of black locust basal bark treatments with varying rates of MAT28 OL, Garlon 4 standard rate, and untreated control along SR1008 east of Bellwood, PA. The trial was evaluated for percent injury on September 26, 2011 (95 days after treatment, DAT) and percent control on June 27, 2012 (370 DAT). Percent mortality was derived by dividing the number of completely controlled stems by 10 (the number treated for each treatment) x 100. Each value is the mean of 10 replicates. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Rate	% Injury 95 DAT	% Control 370 DAT	% Mortality 370 DAT
	(%v/v)			
MAT28 OL	5	60 b	49 b	30
MAT28 OL	10	91 c	76 bc	70
MAT28 OL	15	94 c	92 c	90
MAT28 OL	20	99 c	100 c	100
Garlon 4	20	100 c	100 c	100
Untreated	---	0 a	0 a	0

Table 2. Percent injury, control, and mortality of sugar maple basal bark treatments with varying rates of MAT28 OL, Garlon 4 standard rate, and untreated control along SR1008 east of Bellwood, PA. The trial was evaluated for percent injury on September 26, 2011 (95 days after treatment, DAT) and percent control on July 25, 2012 (403 DAT). Percent mortality was derived by dividing the number of completely controlled stems by 10 (the number treated for each treatment) x 100. Each value is the mean of 10 replicates. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Rate	% Injury 95 DAT	% Control 403 DAT	% Mortality 403 DAT
	(%v/v)			
MAT28 OL	5	88 b	94 b	80
MAT28 OL	10	91 b	100 b	100
MAT28 OL	15	88 b	99 b	90
MAT28 OL	20	100 b	100 b	100
Garlon 4	20	100 b	100 b	100
Untreated	---	10 a	22 a	0

Table 3. Percent injury, control, and mortality of red oak basal bark treatments with varying rates of MAT28 OL, Garlon 4 standard rate, and untreated control at the N. Atherton exit ramp of I-99N in State College, PA. The trial was evaluated for percent injury on September 28, 2011 (97 days after treatment, DAT) and percent control on August 6, 2012 (415 DAT). Percent mortality was derived by dividing the number of completely controlled stems by 10 (the number treated for each treatment) x 100. Each value is the mean of 10 replicates. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Rate	% Injury 97 DAT	% Control 415 DAT	% Mortality 415 DAT
	(%v/v)			
MAT28 OL	5	16 ab	82 b	30
MAT28 OL	10	14 ab	86 b	20
MAT28 OL	15	22 ab	74 b	40
MAT28 OL	20	38 b	98 b	80
Garlon 4	20	93 c	98 b	90
Untreated	---	0 a	9 a	0

COMPARISON OF HERBICIDE AND MOWING REGIMES FOR CONTROL OF CANADA THISTLE IN A GRASS GROUNDCOVER – THIRD YEAR RESULTS

Herbicide trade and common names: Milestone VM (*aminopyralid*), Overdrive (*dicamba + diflufenzopyr*), Perspective (*aminocyclopyrachlor + chlorsulfuron*), Triplet LO or Lesco Three Way (2*,4-D + mecoprop-p + dicamba*).
Plant common and scientific names: Canada thistle (*Cirsium arvense*).

ABSTRACT

Canada thistle is a common perennial state and federal noxious weed found throughout Pennsylvania. It has the ability to spread by seed and vegetatively by means of an aggressive colonizing root system. Mowing has been the standard approach to curb seed dispersal; however, mowing does not prevent continued colony expansion by the root system. A recent program to save energy and reduce maintenance costs was implemented by reducing the number and extent of mowing operations along roadways. This program has resulted in greater seed distribution and an increase in overall Canada thistle. In an effort to address Canada thistle expansion while effectively managing costs, a long-term study of alternative management strategies was initiated. This study consists of a two-season two-step program, a spring treatment of either mowing or herbicide treatment (chemical mowing). Followed by a fall mowing or application of one of the following herbicides or herbicide combinations: Milestone VM (*aminopyralid*), combinations of Milestone VM + Overdrive (*dicamba + diflufenzopyr*), or combinations of Perspective (*aminocyclopyrachlor + chlorsulfuron*) + Overdrive was undertaken in fall of 2010. Two sites with one near the Mountville exit on SR 30 and the other near an entrance ramp to SR 422 near Indiana, PA were chosen for the trial. Initial cover by Canada thistle was 5.5% and 44% at the Mountville and Indiana sites, respectively. Approximately one year after initial treatment (370 days after initial treatment, DAIT, for the Mountville site and 362 DAIT for the Indiana site), all treatment sequences reduced Canada thistle populations compared to the initial stem counts. At one year after the initial treatment, the number of Canada thistle stems was significantly lower at the Indiana site for plots treated with a fall herbicide application as compared to fall mowing. This trend continued through a second season of evaluation and treatments. It appears the incorporation of fall applied herbicide treatments enhanced the control of Canada thistle compared to mowing alone. Mowing two times per season without the incorporation of herbicide treatments was effective only where turf and other existing vegetation was able to compete against the Canada thistle stand. Overall, a competitive grass cover may have contributed to the effectiveness of the treatments at both sites. Continued treatment and assessment of the sites will determine if complete elimination of the Canada thistle stand can be achieved and maintained.

INTRODUCTION

Canada thistle is a noxious perennial weed common to farmland and roadside in Pennsylvania. Reducing the spread of this pest on the right-of-way is an important consideration for vegetation managers. The extensive creeping root system can reach a depth of three feet and produce numerous root suckers along its laterally branching roots. An added concern is the movement and long-term viability of seed that are reported to be viable in the soil for more than

20 years.[1] To be effective, control measures must prevent seed production and exhaust the energy stored in the existing root system. This is typically accomplished by mowing or applying herbicide two times each year (spring and fall) for multiple years followed by an ongoing maintenance program.[2]

In the fall of 2010, a study repeated at two locations was initiated to evaluate the effectiveness of various combinations of spring and fall herbicide and mowing strategies at reducing Canada thistle populations in areas where grass was the predominant ground cover. The treatments consisted of mowing or chemical mowing to limit the aboveground growth in the spring control followed by a fall control treatment of either mowing or an application of herbicide. The herbicides used as fall control were Milestone VM alone, combinations of Milestone VM + Overdrive, and Perspective + Overdrive. This study was conducted to determine if a twice per year treatment program applied over multiple years can be an effective strategy for controlling Canada thistle in a turf environment. A previous report details first year findings of this trial.[3] This is a report of the results after two years of repeated treatments.

MATERIALS AND METHODS

The study was replicated at two sites, one on the shoulder of SR30W near the Mountville exit and the second next to the SR422E entrance ramp near Indiana, PA. The six treatments consisted of: 1) mow spring and fall, 2) mow spring and apply Milestone VM (*aminopyralid*) at 7 oz/ac fall, 3) mow spring and apply Milestone VM at 7 oz/ac + Overdrive (*dicamba* + *diflufenzopyr*) at 4 oz/ac fall, 4) mow spring and apply Perspective (*aminocyclopyrachlor* + *chlorsulfuron*) at 2 oz/ac + Overdrive at 4 oz/ac fall, 5) chemical mow spring with Triplet LO or Lesco Three-Way (*2,4-D* + *mecoprop* +*dicamba*) at 64 oz/ac and apply Milestone VM at 7 oz/ac + Overdrive at 4 oz/ac fall, 6) chemical mow with Triplet LO or Lesco Three-Way at 64 oz/ac spring and apply Perspective at 2 oz/ac + Overdrive at 4 oz/ac fall, All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v.

Plot sizes were 30 by 40 feet and 18 by 30 feet for the Mountville and Indiana sites, respectively. Mowing was performed at a height of approximately 4 inches with a Stihl FS 90 or 550 brush saw equipped with a metal brush cutting blade or rotary push mower. Herbicides were applied at 50 gal/ac with a CO_2 powered backpack sprayer equipped with a 6 foot boom and four 8004-VS spray nozzles. Both trials were arranged in a randomized complete block design with three replications.

Canada thistle stem counts were obtained by counting the number of stems in an 11 sq ft. subplot at a randomly chosen but fixed location within each plot. Percent cover by Canada thistle and grass species was estimated by visual observation. The first treatments were performed and initial Canada thistle stem counts taken on September 17, 2010 and September 24, 2010 for the Mountville and Indiana sites, respectively. The Mountville site was evaluated for number of Canada thistle stems and ongoing treatments were applied on May 26 and September 22, 2011, at 251 and 370 days after initial treatment (DAIT) and May 22 and October

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[1] Thurnhurst, G. and Swearingen, J.M. 2005. DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers – Canada thistle Cirsium arvense (.L) Scop. http://www.dcnr.state.pa.us/forestry/invasivetutorial/canada-thistle.htm.

[2] Gover et al. 2007. Conservation Reserve Enhancement Program (CREP) Technical Assistance Series Factsheet 1 – Managing Canada Thistle. http://horticulture.psu.edu/research/labs/vegetative - management/publications

[3] Johnson et al. 2012. Comparison of Herbicides and Mowing Regimes for Control of Canada Thistle in a Grass Groundcover. Roadside Vegetation Management Research – 2012 Report. pp. 1-5.

11, 2012, at 613 and 755 DAIT. The Indiana site was evaluated for Canada thistle stems and ongoing treatments were applied on May 24 and September 21, 2011, at 242 and 362 days after initial treatment (DAIT) and May 24 and September 20, 2012, at 608 and 727 DAIT. Starting in September 2011 the total vegetative cover, cover by turf, and cover by Canada thistle within each plot and at both locations was also recorded. Quantitative data were subjected to analysis of variance. When treatment effect F tests were significant ($p \leq 0.05$), means were compared using the Tukey HSD test.

RESULTS AND DISCUSSION

Initial Canada thistle cover averaged 5.5% at the Mountville location. The average number of Canada thistle stems per subplot ranged from 33 to 62 at the onset of the trial and there were no significant differences among the anticipated treatments. At 370 DAIT the stem count declined for all treatments with no significant differences and averaged 0 to 8 stems per subplot. Stem numbers continued to decline and at 755 DAIT no Canada thistle stems were present within any of the subplots for all treatments (Table 1). A small amount of Canada thistle was present within the mow only treatment but outside of the subplots and representing 1 percent of the total cover. Meanwhile, cover by turf showed an increase over this time period. At 370 and 755 DAIT turf cover was not significantly different between treatments and ranged from 50 to 63 and 82 to 92 percent, respectively (Table 2).

At the start of this trial, Canada thistle cover at the Indiana site averaged 44%. The initial number of Canada thistle stems per subplot averaged from 45 to 81 for the scheduled treatments. Over the next two seasons the number of Canada thistle stems was greatly reduced for all treatments that utilized a fall herbicide treatment. At 362 and 727 DAIT all treatments, except mowing twice per year, had an average Canada thistle stem count ranging from 0 to 9 and 0 to 8 per subplot, respectively. The chemical treatments were not significantly different. Two mowings per season did not result in a significant decline in Canada thistle stems over that same period. The progression for this mowing treatment went from an initial count of 60 stems to 55 and 45 stems per subplot at 362 and 727 DAIT and was significantly different than other treatments at the later two dates (Table 3). An evaluation of Canada thistle cover at 727 DAIT resulted in a similar trend in reduced Canada thistle cover with a 40 percent cover when mowing twice per season and 0 to 3 percent cover for all treatments where a fall applied herbicide was used. Cover by turf was high for treatments that utilized herbicides at both 362 and 727 DAIT and ranged from 98 to 99 and 95 to 99 percent, respectively, with no significant differences. Mowing twice per season with no herbicide applied had significantly less turf cover at both 362 and 727 DAIT with values of 52 and 48 percent (Table 4).

CONCLUSIONS

Results two years after initiating the study indicate that all treatments, except mowing two times per year, reduced the number of Canada thistle stems with continued use of treatments over this time period. The incorporation of fall applied herbicide treatments enhanced the control of Canada thistle compared to mowing alone. Mowing two times per season without the incorporation of herbicide treatments was effective only where turf and other existing vegetation was able to compete against the Canada thistle stand. Overall, a competitive grass cover may have contributed to the effectiveness of all treatments at both sites. The same mowing and herbicide regimes tested in this study should be applied on sites where turf is not well established or where broadleaf vegetation is the primary groundcover and considered as a topic for additional study.

MANAGEMENT IMPLICATIONS

Management strategies that employ a spring mowing or herbicide treatment followed by a fall applied herbicide component seem to be effective at reducing the number of Canada thistle stems in a turf environment even after the first year of treatment. In areas that can be mowed, the spring treatment could be one of the mowing cycles that are routinely used in a roadside maintenance program followed by a targeted application of an appropriate herbicide in the fall. In areas that do not lend themselves to mowing due to steep grades, rough terrain, or other obstacles, two herbicide applications each year would be necessary to prevent seed production and reduce thistle stem populations.

Table 1. Canada thistle stem counts for the SR 30 trial site near **Mountville PA**. Initial treatments and evaluations were conducted on September 17, 2010. Subsequent treatments and evaluations were performed on May 26 and September 22, 2011, 251 and 370 days after initial treatment (DAIT) and May 22 and October 11, 2012, 613 and 755 DAIT. Numbers represent the mean of three replications. Column means followed by the same letter are not significantly different at p≤0.05.

Treatment	Initial Stem Count September 2010	Stem Count September 2011 370 DAIT	Stem Count October 2012 755 DAIT
Mow Spring and Fall	33 a	8 a	0 a
Mow Spring, Milestone Fall	33 a	0 a	0 a
Mow Spring, Milestone + Overdrive Fall	43 a	1 a	0 a
Mow Spring, Perspective + Overdrive Fall	38 a	0 a	0 a
Chemical Mow Spring, Milestone + Overdrive Fall	62 a	0 a	0 a
Chemical Mow Spring, Perspective + Overdrive Fall	39 a	0 a	0 a

Table 2. Percent cover by turf at 370 and 755 days after initial treatment (DAIT) and Canada thistle at 755 DAIT for the SR 30 trial near **Mountville PA**. Initial treatments and evaluations were conducted on September 17, 2010. Subsequent treatments and evaluations occurred on May 26 and September 22, 2011, 251 and 370 DAIT and May 22 and October 11, 2012, 613 and 755 DAIT. Numbers represent the mean of three replications. Column means followed by the same letter are not significantly different at p≤0.05.

	Turf Cover		Canada thistle Cover
Treatment	September 2011 370 DAIT	October 2012 755 DAIT	October 2012 755 DAIT
Mow Spring and Fall	63 a	87 a	1 a
Mow Spring, Milestone Fall	55 a	82 a	0 a
Mow Spring, Milestone + Overdrive Fall	50 a	92 a	0 a
Mow Spring, Perspective + Overdrive Fall	53 a	92 a	0 a
Chemical Mow Spring, Milestone + Overdrive Fall	58 a	89 a	0 a
Chemical Mow Spring, Perspective + Overdrive Fall	63 a	91 a	0 a

Table 3. Canada thistle stem counts for the SR 422 trial site near **Indiana PA**. Initial treatments and evaluations were conducted on September 24, 2010. Subsequent treatments and evaluations were performed on May 24 and September 21, 2011, 242 and 362 days after initial treatment (DAIT) and May 24 and September 20, 2012, 608 and 727 DAIT. Numbers represent the mean of three replications. Column means followed by the same letter are not significantly different at p≤0.05.

Treatment	Initial Stem Count September 2010	Stem Count September 2011 362 DAIT	Stem Count September 2012 727 DAIT
Mow Spring and Fall	60 a	55 a	45 a
Mow Spring, Milestone Fall	58 a	5 b	8 b
Mow Spring, Milestone + Overdrive Fall	59 a	1 b	0 b
Mow Spring, Perspective + Overdrive Fall	81 a	9 b	1 b
Chemical Mow Spring, Milestone + Overdrive Fall	74 a	0 b	0 b
Chemical Mow Spring, Perspective + Overdrive Fall	45 a	1 b	0 b

Table 4. Percent cover by turf at 362 and 727 days after initial treatment (DAIT) and Canada thistle at 727 DAIT for the SR 422 trial near **Indiana PA**. Initial treatments and evaluations were conducted on September 24, 2010. Subsequent treatments and evaluations occurred on May 24 and September 21, 2011, 242 and 362 DAIT and May 24 and September 20, 2012, 608 and 727 DAIT. Numbers represent the mean of three replications. Column means followed by the same letter are not significantly different at p≤0.05.

	Turf Cover		Canada thistle Cover
Treatment	September 2011 362 DAIT	September 2012 727 DAIT	September 2012 727 DAIT
Mow Spring and Fall	52 a	48 a	40 a
Mow Spring, Milestone Fall	98 b	95 b	3 b
Mow Spring, Milestone + Overdrive Fall	99 b	98 b	1 b
Mow Spring, Perspective + Overdrive Fall	98 b	98 b	1 b
Chemical Mow Spring, Milestone + Overdrive Fall	99 b	99 b	0 b
Chemical Mow Spring, Perspective + Overdrive Fall	99 b	99 b	0 b

CONVERSION OF CANADA THISTLE INFESTED CROWNVETCH GROUNDCOVER TO FINE FESCUE TURF – DETAILS OF TRIAL ESTABLISHMENT

Herbicide trade and common names: Garlon 3A (*triclopyr*), Milestone VM (*aminopyralid*), PDT Custom Blend (*aminocyclopyrachlor + metsulfuron*), Roundup Pro Concentrate (*glyphosate*), Transline (*clopyralid*).

Plant common and scientific names: Annual ryegrass (*Lolium multiflorum*), Canada thistle (*Cirsium arvense*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), hard fescue (*Festuca longifolia*).

ABSTRACT

Crownvetch is an effective groundcover on steep slopes with rocky mineral soils; however, on sites with well-developed topsoil characterized by higher levels of organic matter this groundcover often becomes overrun with difficult to control broadleaf weeds such as Canada thistle. Steep, inaccessible site conditions often restrict mowing options. Herbicides that will spare the crownvetch yet provide some control of broadleaf weeds is limited. Converting an area from crownvetch while eliminating the Canada thistle may be a more effective maintenance approach in that it allows for better future broadleaf control. An effective conversion strategy is to use herbicides to control both the Canada thistle and crownvetch followed by the establishment of fine fescue turf. Fine fescue provides a level of allelopathic and competitive control against broadleaf weeds, requires limited to no mowing, and allows for more broad-spectrum broadleaf weed control. This may be an attractive option for vegetation managers on certain sites. Some effective broadleaf herbicides persist in the soil after application and may inhibit the germination of desirable turfgrass seeds during the conversion. This experiment was established to determine the effectiveness of various herbicide treatments for controlling crownvetch and Canada thistle while defining the best timing for seeding following the application. For this experiment a fall herbicide application was employed with a comparison of a same season fall seeding versus a spring seeding in determining the best time for establishing a fine fescue stand and herbicide residual impact. The herbicide treatments included: 1) Milestone VM at 7 oz/ac, 2) Roundup Pro Concentrate at 104 oz/ac + Transline at 8 oz/ac, 3) PDT Custom Blend at 8 oz/ac, 4) PDT Custom Blend at 4 oz/ac + Garlon 3A at 64 oz/ac, and 5) cut only – no herbicide applied control. The plots have been disced, seeded with PennDOT Formula L seed mix (Table 1) at 24 lbs per 1000 sq. yds., and fertilized according to soil test recommendations at 1 lb. N, 5.0 lbs. P_2O_5, and 0.5 lbs. or 2 lbs. K_2O per 1000 sq. ft. This report is a summary of the initiation of this experiment.

INTRODUCTION

Crownvetch can provide a groundcover on steep slopes where rocky, mineral soils predominate. On sites with adequate organic matter and moderate terrain, crownvetch can contribute to maintenance concerns because it easily becomes infested with difficult to control, broadleaf weeds such as Canada thistle. Herbicides that can be used for broadleaf weed control in this groundcover are limited. Converting crownvetch groundcover into turf is an attractive option to simplify ongoing maintenance procedures because more options for broadleaf weed control are available in turf; specifically, more frequent mowing and a wider range of herbicides.

Previous research has indicated that a number of herbicide tank mixes have been effective at controlling Canada thistle and crownvetch in turf environments.[1] Some of the herbicides used to remove crownvetch have residual effects in the soil that may inhibit germination of desirable seeds for some time after application. The purpose of this experiment was to evaluate several herbicides or herbicide tank mixes for control of crownvetch and Canada thistle and determine the best time to seed turf following a fall application of these herbicide treatments. This report is a summary of the initiation of this experiment.

MATERIALS AND METHODS

The experiment was established at two sites with predominantly crownvetch groundcover infested with Canada thistle, one on the shoulder of SR 322E near the Old Fort exit, 5 miles east of State College and the second in the median of SR 322 near Thompsontown. Both sites were organized into 24 by 30 foot plots in a randomized complete block design with 4 replications.

All plots were mowed on June 21 and 28, 2012, respectively with a tractor mounted flail mower at a height of 5 inches to simulate the standard maintenance practice used to remove Canada thistle seed heads and reduce seed dispersal. Herbicide treatments were applied on September 5 and September 7 at the Old Fort and Thompsontown sites, respectively. Soil on the fall-seeded plots was prepared immediately prior to seeding using a disc harrow mounted on a Kubota L2500 tractor. These plots were then seeded with PennDOT Formula L seed mix (Table 1) at 24 lbs. per 1000 sq. yds., approximately 6 weeks after application of the herbicide treatments. The remaining plots were prepared, seeded, and fertilized in the spring of 2013. The amount of fertilizer applied was based on soil test result recommendations from the Penn State Agricultural Analytical Services Laboratory and were equivalent to 1 lb. N, 5.0 lbs. P_2O_5, and 0.5 lbs. or 2 lbs. K_2O per 1000 sq. yds. on all plots at both sites (i.e., Old Fort and Thompsontown, respectively).

The herbicide treatments included: 1) Milestone VM at 7 oz/ac, 2) Roundup Pro Concentrate at 104 oz/ac + Transline at 8 oz/ac, 3) PDT Custom Blend at 8 oz/ac, 4) PDT Custom Blend at 4 oz/ac + Garlon 3A at 64 oz/ac, and 5) cut only – no herbicide applied control plots. All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v and were applied with a CO_2 powered backpack sprayer at 35 psi with a 6 ft. boom equipped with four 8004VS nozzles. Pre-treatment, Canada thistle stem counts were obtained by counting and averaging the number of stems in three 11 sq. ft. subplots at fixed locations within each plot and will be summarized in future reports as more data is collected. Coverage collected for seeded grasses will be determined by a visual rating of the plots.

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[1] Johnson et al. 2012. Comparison Of Herbicide And Mowing Regimes For Control Of Canada Thistle In A Grass Groundcover. 2012 Roadside Vegetation Management Report. pp. 1-5.

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

Scientific Name	Common Name	Seeding Rate lbs/1000 sq yd
Festuca longifolia	hard fescue	13.0
Festuca rubra	creeping red fescue	8.5
Lolium multiflorum	annual ryegrass	2.5

EVALUATION OF AMINOCYCLOPYRACHLOR COMBINATIONS FOR SPRING APPLIED BROADLEAF TREATMENTS IN TURF

Herbicide trade and common names: Escort XP or MSM (*metsulfuron*), MAT28 50SG or MAT 240SL (*aminocyclopyrachlor*), Milestone VM (*aminopyralid*), Millenium Ultra (*2,4-D, clopyralid, dicamba*), Opensight (*aminopyralid plus metsulfuron*), Perspective (*aminocyclopyrachlor plus chlorsulfuron*), Plateau (*imazapic*), Streamline or Custom Blend (*aminocyclopyrachlor plus metsulfuron*), Telar XP (*chlorsulfuron*).

Plant common and scientific names: crownvetch (*Coronilla varia*, CZRVA), dandelion (*Taraxacum officinale*, TAROF), Kentucky bluegrass (*Poa pratensis*, POAPR), tall fescue (*Festuca arundinacea*, FESAR), wild carrot (*Daucus carota*, DAUCA).

ABSTRACT

A well-maintained groundcover is an important asset on the roadside right-of-way. Groundcovers protect soils from erosion, provide competition for undesirable plant species, remain low growing to allow for sight-distance, and are aesthetically appealing. Often turf is used as the preferred groundcover and maintained with mowing and broadleaf herbicide treatments. There are many broadleaf herbicides on the market for use in perennial, cool-season turf stands. However, a recently introduced active ingredient, *aminocyclopyrachlor*, presents a new class of chemistry, which provides extended residual control. DuPont released three new herbicide premixes containing the active ingredient *aminocyclopyrachlor* that received EPA registration in 2011 and two (i.e., Perspective and Streamline) are labeled for use on well-established and unimproved roadside turf areas. The active ingredient *aminocyclopyrachlor* was also tested using experimental formulations of MAT 240SL containing 21.2% ae *aminocyclopyrachlor* combined with MSM (1.25 lb *metsulfuron*/gal). The Custom Blend is a combination of 5.67 oz MAT28 (50% *aminocyclopyrachlor*) and 0.33 oz Escort XP (60% *metsulfuron*) in 6 oz of product. This experiment was established to investigate the efficacy of these and other products for control of several common broadleaf weed species and safety to turf.

Treatments containing *aminocyclopyrachlor* provided excellent control of the three broadleaf species present in the plots with no signs of turf injury. The rates of Escort XP or Telar XP found in the higher rates of Streamline or Perspective tested would normally be a concern regarding turf safety. Possibly, the spring timing and optimal growing conditions at the time of treatment provided an advantage to the grasses and prevented development of significant injury symptoms. This suggests that Perspective or Streamline (especially at the lower rates tested), the Custom Blend, and the experimental formulations of MAT 240 SL plus MSM may provide excellent broadleaf weed control and offer a margin of safety under similar environmental conditions to common turf species found along Pennsylvania's roadways with spring-applied treatments.

INTRODUCTION

Effective broadleaf weed control is critical to improving quality, reducing maintenance costs, and increasing the aesthetic appeal of roadside turf. There are many selective herbicides and combinations commercially available for general broadleaf weed control in perennial cool-season grass stands. DuPont released three herbicide premixes that received EPA registration in

2011 and contain the new active ingredient, *aminocyclopyrachlor*. Two of the products (Perspective and Streamline) have labeling that allows use on well-established and unimproved roadside turf areas. The labels caution that low use rates are required, temporary discoloration of the turf may occur, and products should be applied in spring after 4 to 6 inches of new growth has developed or alternatively, be applied in the fall.[1,2] MAT 240SL and MSM are experimental liquid formulations containing 21.2% ae *aminocyclopyrachlor* and 1.25 lb *metsulfuron*/gal, respectively, being tested for possible future release. The Custom Blend is a combination of 5.67 oz MAT28 (50% aminocyclopyrachlor) and 0.33 oz Escort XP (60% metsulfuron) in 6 oz of product. *Aminocyclopyrachlor* is a new class of chemistry belonging to the "pyrimidine carboxylic acid family", which mimics the plant growth regulation response found with auxin based herbicides. Also, *aminocyclopyrachlor* has the potential to provide long-term control with a half-life of 4 months or greater in the soil.[3] This trial was established to investigate the efficacy of these and other products for control of several common broadleaf weed species as well as safety to turf.

MATERIALS AND METHODS

The trial site was located on the shoulder of the 322W on ramp near Oak Hall, PA. Plots were nine by twenty-five feet in size and were arranged as a randomized complete block design with three replications. Treatments applied on May 23, 2011 included Perspective or Streamline at 2.75, 3.75, and 4.75 oz/ac rates; Opensight at 3 oz/ac; MAT 240SL at 5.96 oz/ac plus MSM at 3.01 oz/ac; MAT 240SL at 7.52 oz/ac plus MSM at 3.84 oz/ac; Custom Blend at 6 oz/ac alone or with Plateau at 2 oz/ac; Millenium Ultra at 32 oz/ac; and an untreated check. CWC Surfactant 90 at 0.25% v/v was added to all treatments. The application was made at 40 gal/ac using a CO_2-powered backpack sprayer with 9 ft boom and six Teejet 8004VS even flat fan spray tips.

The trial was visually rated for percent injury (phytotoxicity) to tall fescue and Kentucky bluegrass plus percent control of crownvetch, dandelion, and wild carrot on June 27, July 29, October 25, and November 17, 2011 which corresponds to 35, 67, 155, and 178 days after treatment (DAT), respectively.

RESULTS AND DISCUSSION

Prior to the June 27th rating PennDOT contractors sprayed the delineators at the front edge of the trial. Three plots each in rep 1 and 2 and six plots in rep 3 were affected. Most of the dandelion (TAROF) and wild carrot (DAUCA) were located along this edge. Where the front edge of a plot was over sprayed and the vegetation was eliminated, the species within these areas was counted as missing for the remainder of the trial.

No phytotoxicity was observed on either tall fescue or Kentucky bluegrass at any of the rating dates. All phytotoxicity values were recorded as "0" indicating no noticeable

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[1] E.I. du Pont de Nemours and Company. DuPont™ Perspective herbicide. Online. Internet. April 29, 2013. Available www.cdms.net

[2] E.I. du Pont de Nemours and Company. DuPont™ Streamline herbicide. Online. Internet. April 29, 2013. Available www.cdms.net

[3] U.S. Environmental Protection Agency, Registration of the New Active Ingredient Aminocyclopyrachlor for Use on Non-Crop Areas, Sod Farms, Turf, and Residential Lawns. p. 14. August 24, 2010. April 29, 2013. <http://www.google.com/search?client=safari&rls=en&q=aminocyclopyrachlor+half-life&ie=UTF-8&oe=UTF-8>

discoloration was seen. At 35 DAT the percent control between species was variable. Crownvetch ranged from 50 to 85 percent control for the herbicide treatments. Treatments that included the highest rate of Streamline at 4.75 oz/ac or MAT 240SL at 7.52 oz/ac, Opensight at 3 oz/ac, and the Custom Blend at 6 oz/ac with or without Plateau at 2 oz/ac yielded the greatest initial control values between 67 and 85 percent while other treatments ranged from 50 to 58 percent (Table 1). Control of dandelion at 35 DAT ranged from 87 to 100 percent for all treatments except Millenium Ultra at 65 percent (Table 2). Similarly, control of wild carrot ranged from 75 to 100 percent for all treatments, except Millenium Ultra at 25 percent (Table 3). Percent control of the three broadleaf species was nearly complete for all treatments, except Millenium Ultra, when evaluated at 67 DAT and beyond and ranged from 97 to 100 percent. The only exception was a control value of 90 percent for wild carrot at 67 DAT using the lowest rate (2.75 oz/ac) of Streamline. Millenium Ultra offered good control of crownvetch (93 percent) and dandelion (98 percent) by the final rating (178 DAT) but poor control of wild carrot (63 percent). Though statistical differences occurred for dandelion and wild carrot the means were not compared due to missing data.

CONCLUSIONS

Overall, treatments containing aminocyclopyrachlor and aminopyralid provided excellent control of the three broadleaf species present in this trial. Additionally, the turf showed no signs of injury at even the highest rates tested. This suggests that Perspective, Streamline, Opensight, Custom Blend and the experimental formulations of MAT 240 SL plus MSM can provide exceptional broadleaf weed control and offer a margin of safety to the commonly used roadside turf species. Typically, the higher label rates of Escort XP or Telar XP found in Streamline or Perspective would be a cause for concern regarding safety to turf. Perhaps, the spring timing and optimal growing conditions at the time of treatment provided an advantage to the grasses and prevented significant injury symptoms from developing. Care should be taken in that this was a single year experiment. Spring environmental conditions can vary from year to year which may affect herbicide efficacy and potential injury to turf from the herbicides used in this experiment.

MANAGEMENT IMPLICATIONS

Streamline, Perspective, Opensight, and the Custom Blend are potential candidates for the 7713 (Weed and Brush) program. Streamline and Perspective at rates greater than 2.75 oz/ac contain enough metsulfuron (Escort XP) or chlorsulfuron (Telar XP) to potentially injure turf, so the low rate of these products should be utilized. Rates of 2 to 3 oz/ac or greater may damage perennial ryegrass according to the product labels for both Perspective and Streamline, respectively. Alternatively, the Custom Blend can be used alone at 6 oz/ac; however, lower rates of 4 oz/ac should be tested in future experiments for general broadleaf weed control in roadside turf. The use of products containing *aminocyclopyrachlor* is to be avoided around desirable coniferous and deciduous tree roots. Medians, shoulder, and interchange areas along interstate or primary roads with large right-of-way widths would be excellent candidates for use of these products. Opensight is generally recommended at rates of 2 oz/ac for standard broadleaf weed control applications and the label stipulates that injury to tall fescue can occur at rates exceeding 2 oz/ac.[4]

[4] Dow AgroSciences, LLC. Opensight Specialty Herbicide. Online. Internet. April 29, 2013.

Table 1: Percent control of crownvetch (*Coronilla varia*, CZRVA). Percent control was based on a visual rating on June 27 (35 days after treatment, DAT), July 29 (67 DAT), October 25 (155 DAT), and November 17, 2011 (178 DAT). Treatments were applied on May 23, 2011. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at p ≤ 0.05.

		Percent Control CZRVA			
Product	Rate	35 DAT	67 DAT	155 DAT	178 DAT
	(oz/ac)				
Perspective	2.75	50 b	99 b	100 c	100 b
Perspective	3.75	50 b	99 b	99 c	99 b
Perspective	4.75	58 bc	100 b	100 c	100 b
Streamline	2.75	50 b	98 b	99 bc	99 b
Streamline	3.75	50 b	99 b	98 bc	99 b
Streamline	4.75	67 bcd	100 b	100 c	100 b
Opensight	3	85 d	99 b	100 c	100 b
MAT 240SL MSM	5.96 3.01	50 b	100 b	99 c	100 b
MAT 240SL MSM	7.52 3.84	67 bcd	100 b	100 c	100 b
Custom Blend	6	80 cd	99 b	100 c	100 b
Custom Blend Plateau	6 2	75 bcd	99 b	99 c	100 b
Millenium Ultra	32	58 bc	93 b	95 b	93 b
Untreated	---	0 a	0 a	0 a	0 a

Table 2: Percent control of dandelion (*Taraxacum officinale*, TAROF). Percent control was based on a visual rating on June 27 (35 days after treatment, DAT), July 29 (67 DAT), October 25 (155 DAT), and November 17, 2011 (178 DAT). Treatments were applied on May 23, 2011. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of three replications. Significant differences did occur at $p \leq 0.05$ but are not reported due to missing data.

		Percent Control TAROF			
Product	Rate	35 DAT	67 DAT	155 DAT	178 DAT
	(oz/ac)				
Perspective	2.75	87	97	100	99
Perspective	3.75	100	100	100	100
Perspective	4.75	99	100	100	100
Streamline	2.75	97	100	100	100
Streamline	3.75	100	100	100	100
Streamline	4.75	100	100	100	100
Opensight	3	94	100	100	100
MAT 240SL MSM	5.96 3.01	100	100	100	100
MAT 240SL MSM	7.52 3.84	100	100	100	100
Custom Blend	6	100	100	100	100
Custom Blend Plateau	6 2	100	100	100	100
Millenium Ultra	32	65	90	96	98
Untreated	---	0	0	0	0

Table 3: Percent control of wild carrot (*Daucus carota*, DAUCA). Percent control was based on a visual rating on June 27 (35 days after treatment, DAT), July 29 (67 DAT), October 25 (155 DAT), and November 17, 2011 (178 DAT). Treatments were applied on May 23, 2011. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of three replications. Significant differences did occur at $p \leq 0.05$ but are not reported due to missing data.

		Percent Control DAUCA			
Product	Rate	35 DAT	67 DAT	155 DAT	178 DAT
	(oz/ac)				
Perspective	2.75	87	100	100	100
Perspective	3.75	90	100	100	99
Perspective	4.75	83	100	100	100
Streamline	2.75	87	90	100	100
Streamline	3.75	100	100	98	97
Streamline	4.75	100	100	99	99
Opensight	3	75	99	100	100
MAT 240SL MSM	5.96 3.01	100	100	100	100
MAT 240SL MSM	7.52 3.84	98	97	100	100
Custom Blend	6	87	100	100	100
Custom Blend Plateau	6 2	75	100	100	100
Millenium Ultra	32	25	50	48	63
Untreated	---	0	0	0	0

EVALUATION OF AMINOCYCLOPYRACHLOR COMBINATIONS FOR SUMMER APPLIED BROADLEAF TREATMENTS IN TURF

Herbicide trade and common names: Escort XP or MSM (*metsulfuron*), MAT28 or MAT 240SL (*aminocyclopyrachlor*), Matrix (*rimsulfuron*), Millenium Ultra (*2,4-D, clopyralid, dicamba*), Opensight (*aminopyralid + metsulfuron*), PennDOT (PDT) Custom Blend or Streamline (*aminocyclopyrachlor + metsulfuron*), Perspective (*aminocyclopyrachlor + chlorsulfuron*), Plateau (*imazapic*), Telar (*chlorsulfuron*).

Plant common and scientific names: buckhorn plantain (*Plantago lanceolata*, PLALA), crownvetch (*Coronilla varia*, CZRVA), tall fescue (*Festuca arundinacea,* FESAR), wild carrot (*Daucus carota*, DAUCA).

ABSTRACT

Roadside areas are normally planted with a competitive groundcover to discourage the development of unwanted plant species and to offer added benefits such as prevention of soil erosion, protection of sight distance for motorists, and to provide an aesthetically appealing landscape. Several cool-season grass species are used along Pennsylvania's roads as an effective and easily managed competitive groundcover. The management of a turf stand often involves mowing and occasional herbicide treatments to remove dicot species. There are many herbicides labeled for control of broadleaf weeds in roadside turf areas. However a recently introduced active ingredient, *aminocyclopyrachlor*, is a new class of chemistry that offers extended residual control. DuPont released three new herbicide premixes containing *aminocyclopyrachlor* that received EPA registration in 2011 of which two products (i.e., Perspective and Streamline) are labeled for use on well-established and unimproved roadside turf areas. The active ingredient *aminocyclopyrachlor* was also tested using MAT28 (50% aminocyclopyrachlor) in combination with Matrix or Escort XP (i.e., PennDOT Custom Blend). Additionally, an experimental formulation referred to as MAT 240SL containing 21.2% ae *aminocyclopyrachlor* combined with MSM (1.25 lb metsulfuron/gal) was investigated. In this experiment the efficacy of these and other products for control of buckhorn plantain, crownvetch, and wild carrot were evaluated in conjunction with the safety of these products on roadside turf. Treatments containing *aminocyclopyrachlor* provided excellent control of the three broadleaf species present in this trial but also displayed transient signs of turf injury. This suggests that Perspective or Streamline, the PennDOT Custom Blend, and the experimental formulations of MAT 240 SL plus MSM will provide excellent broadleaf weed control but may temporarily injure common turf species found along Pennsylvania's roadways with summer applied treatments. The combination of MAT28 plus Matrix at the rates tested provided significant injury to the turf and reduced control of crownvetch and should be avoided for this application.

INTRODUCTION

Roadside managers rely on groundcovers to provide a host of functions and benefits for the roadway corridor. Cool-season turf grass species are often used to provide protection from soil erosion; compete against weeds; create a low growing plant community to allow sight-distance for the motoring public; and offer a uniform, aesthetically appealing landscape. These turf groundcovers are generally easier to manage by both mowing and occasional herbicide treatments than alternative broadleaf groundcovers (e.g. crownvetch). Currently there are many broadleaf herbicides that aid in keeping these turf areas weed-free. However, new chemistry is sometimes introduced and requires investigation to verify the effectiveness for selective weed control treatments within these cool-season turf areas. DuPont released three herbicide premixes that received EPA registration in 2011 and contain the new active ingredient, *aminocyclopyrachlor*. Two of the products, Perspective and Streamline, have labeling that allow for use on well-established and unimproved roadside turf areas. The labels caution that low use rates are required, temporary discoloration of the turf may occur, and products should be applied in spring after 4 to 6 inches of new growth has developed or fall.[1,2] MAT 240SL and MSM are experimental liquid formulations containing 21.2% ae *aminocyclopyrachlor* and 1.25 lb *metsulfuron*/gal, respectively, being tested for possible future application. The addition of Matrix (*rimsulfuron*) to MAT28 was investigated because it offers supplemental labeling for selective weed control in non-crop areas with preemergence and early postemergence control of several common annual grass and broadleaf species. The PennDOT Custom Blend is a combination of 7.67 oz MAT28 (50% *aminocyclopyrachlor*) and 0.33 oz Escort XP (60% *metsulfuron*) in 8 oz of product. One benefit of *aminocyclopyrachlor* is that it is a new class of chemistry belonging to the pyrimidine carboxylic acid class and mimicking auxin activity. *Aminocyclopyrachlor* also has a potential half-life of 4 months or greater in the soil making it a fairly persistent chemical that could prevent further weed development for an extended period of time.[3] This experiment was established to test the efficacy of these and other products for control of several common broadleaf weed species and safety to turf during a summer application.

MATERIALS AND METHODS

The study site was located in the median of I-99 near St. Clairsville, PA. Plots were nine by twenty-five feet in size and were arranged in a randomized complete block design with three replications. Fall-applied treatments included Perspective or Streamline at both 3.75 and 4.75 oz/ac rates; Opensight at 3 oz/ac; MAT28 at 3.76 oz/ac plus Matrix at 2 or 4 oz/ac; MAT 240SL at 5.96 oz/ac plus MSM at 3.01 oz/ac; MAT 240SL at 7.52 oz/ac plus MSM at 3.84 oz/ac; PennDOT Custom Blend at 8 oz/ac alone or with Plateau at 2 oz/ac; Millenium Ultra at 32 oz/ac; and an untreated check. CWC Surfactant 90 at 0.25% v/v was added to all treatments. Treatments were applied on July 14, 2011 at 40 gal/ac using a CO_2-powered backpack sprayer with 9 ft boom and six Teejet 8004VS even flat fan spray tips.

Percent phytotoxicity to tall fescue plus percent control of crownvetch, buckhorn plantain, and wild carrot was rated on August 10 and November 3, 2011, 27 and 112 DAT, respectively. Percent injury to tall fescue and percent control of crownvetch, buckhorn plantain, and wild carrot was rated on April 20, May 16, and June 27, 2012, 281, 307, and 349 DAT.

Percent phytotoxicity to tall fescue was based on the following scale: 10% = slight discoloration; 25% = mild discoloration/chlorosis, unacceptable and likely to thin stand; 50% =

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[1] E.I. du Pont de Nemours and Company. DuPont™ Perspective herbicide. Online. Internet. April 29, 2013. Available www.cdms.net

[2] E.I. du Pont de Nemours and Company. DuPont™ Streamline herbicide. Online. Internet. April 29, 2013. Available www.cdms.net

[3] U.S. Environmental Protection Agency, Registration of the New Active Ingredient Aminocyclopyrachlor for Use on Non-Crop Areas, Sod Farms, Turf, and Residential Lawns. p. 14. August 24, 2010. April 29, 2013. <http://www.google.com/search?client=safari&rls=en&q=aminocyclopyrachlor+half-life&ie=UTF-8&oe=UTF-8>

moderate discoloration/chlorosis, unacceptable and likely to thin stand. Percent injury to tall fescue from 281 DAT and beyond represents a visible stand reduction, not noticeable color difference. A change in turfgrass species composition may have occurred.

At 27 DAT the percent control rating for various broadleaf species were based on the following scale: 25% = slight curling, some chlorosis and leaf loss; 50% = moderate epinasty, some chlorosis, moderate loss of foliage; 85% = significant epinasty, necrosis, and/or loss of foliage; 90% = more severe epinasty, necrosis, and/or loss of foliage; 100% = complete control, eliminated all green portions of plant. Evaluations of percent control from 112 DAT and beyond, is a reflection of the percent reduction for that species based on the percent present at the initiation of the trial for a given plot.

RESULTS AND DISCUSSION

All treatments, except Millenium Ultra, caused phytotoxicity to tall fescue at 27 DAT (Table 1). The phytotoxicity was similar and ranged from 15 to 28 percent for these treatments, except MAT28 plus Matrix that averaged 50 percent. In all cases the symptoms were transient and disappeared by 112 DAT; however, a potential for stand thinning does exist. Injury to the tall fescue in the form of a visible stand reduction was observed with MAT28 plus Matrix treatments at both 281 (50 and 30) and 307 DAT (37 and 30), but by later in the growing season the year following treatment (349 DAT) the tall fescue stand was not noticeably different than untreated areas.

All treatments, except MAT28 plus Matrix, were effective at controlling crownvetch and ranged from 78 to 97 percent at 27 DAT (Table 2). Nearly complete control from 96 to 100 percent was observed by these treatments at 112 through 349 DAT. MAT28 plus Matrix treatments provided statistically less control of this species over the same period and ranged from 52 to 88 percent. Buckhorn plantain did not respond as quickly to the treatments and at 27 DAT only 50 percent control was achieved by all treatments, except the PennDOT Custom Blend with or without Plateau showing 75 and 58 percent control (Table 3). Beyond 112 DAT, all treatments were effective in eliminating buckhorn plantain and ranged from 93 to 100 percent control. Wild carrot was the final weed species evaluated for control using these products. All treatments provided effective and similar control of wild carrot throughout the duration of this trial, except Millenium Ultra (17 to 45 percent, Table 4). At 27 DAT, the treatments ranged from 73 to 93 percent control and maintained 91 to 99 percent control through 349 DAT.

CONCLUSIONS

Treatments containing *aminocyclopyrachlor* provided excellent control of the three broadleaf species present in this trial but also displayed transient signs of turf injury. The rates of Escort XP or Telar XP found in the treatments tested in this trial can be a concern regarding turf safety. Possibly, herbicide treatments made during spring or fall with optimal growing conditions will provide an advantage to the grasses and prevent significant injury symptoms from developing.[4] This suggests that Perspective or Streamline, the PennDOT Custom Blend, and the experimental formulations of MAT 240 SL plus MSM will provide excellent broadleaf weed control but may

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[4] Johnson, et al. 2013. Evaluation of Aminocyclopyrachlor Combinations for Spring Applied Broadleaf Treatments in Turf. Roadside Vegetation Management Research – 2013 Report. pp 24-30.

temporarily injure common turf species found along Pennsylvania's roadways with summer applied treatments. The combination of MAT28 plus Matrix at the rates tested provided significant injury to the turf and limited control of crownvetch and should be avoided for this application.

MANAGEMENT IMPLICATIONS

Streamline, Perspective, Opensight, and the PennDOT Custom Blend are potential candidates for the 7713 (Selective Weed) program. Streamline and Perspective contain enough *metsulfuron* (Escort XP) or *chlorsulfuron* (Telar XP) to typically cause concern of injury to turf; however, so lower rates of these products should be utilized. Rates of 2 to 3 oz/ac or greater may have detrimental effects on perennial ryegrass according to the product labels for both Perspective and Streamline, respectively. Alternatively, the PennDOT Custom Blend can be used alone at 6 oz/ac and rates of 4 oz/ac should be tested for general broadleaf weed control in roadside turf.[5] Opensight is generally recommended at rates of 2 oz/ac for standard broadleaf weed control applications and the label stipulates that injury to tall fescue can occur at rates exceeding this.[6] If using these products for broadleaf weed control in turf on the right-of-way they should be used during periods of vigorous turf growth in the spring or fall. The use of products containing *aminocyclopyrachlor* is to be avoided around desirable tree roots. Medians, shoulder, and interchange areas along interstate or primary roads with large right-of-way widths and no potential for harming non-target trees would be excellent candidates for use of these products at the proper timing.

[5] Johnson, et al. 2013. Evaluation of Aminocyclopyrachlor Combinations for Spring Applied Broadleaf Treatments in Turf. Roadside Vegetation Management Research – 2013 Report. pp 24-30.
[6] Dow AgroSciences, LLC. Opensight Specialty Herbicide. Online. Internet. April 29, 2013. Available www.cdms.net.

Table 1: Percent phytotoxicity and injury to tall fescue (*Festuca arundinacea*, FESAR). The trial was visually rated for percent phytoxicity to FESAR on August 10 (27 days after treatment, DAT) and November 3, 2011 (112 DAT). Percent injury to FESAR was evaluated April 20 (281 DAT), May 16 (307 DAT), and June 27, 2012 (349 DAT). Treatments were applied on July 14, 2011. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		% Phytotoxicity		% Injury FESAR		
Product	Rate	27 DAT	112 DAT	281 DAT	307 DAT	349 DAT
	(oz/ac)					
Perspective	3.75	15 ab	0	0	0 b	0
Perspective	4.75	20 b	0	0	0 b	0
Streamline	3.75	25 b	0	0	0 b	0
Streamline	4.75	25 b	0	0	0 b	0
Opensight	3	20 b	0	0	0 b	0
MAT28 Matrix	3.76 2	50 c	0	30	30 a	0
MAT28 Matrix	3.76 4	50 c	0	50	37 a	0
MAT 240SL MSM	5.96 3.01	20 b	0	0	0 b	0
MAT 240SL MSM	7.52 3.84	28 b	0	0	0 b	0
PDT Custom Blend	8	20 b	0	0	0 b	0
PDT Custom Blend Plateau	8 2	25 b	0	0	0 b	0
Millenium Ultra	32	0 a	0	0	0 b	0
Untreated	---	0 a	0	0	0 b	0
		---	N.S.	N.S.	---	N.S.

Table 2: Percent control of crownvetch (*Coronilla varia*, CZRVA). The trial was visually rated for percent control on August 10 (27 days after treatment, DAT) and November 3, 2011 (112 DAT), plus April 20 (281 DAT), May 16 (307 DAT), and June 27, 2012 (349 DAT). Treatments were applied on July 14, 2011. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Percent Control CZRVA				
Product	Rate	27 DAT	112 DAT	281 DAT	307 DAT	349 DAT
	(oz/ac)					
Perspective	3.75	88 cd	100 b	100 c	100 b	100 c
Perspective	4.75	87 cd	100 b	100 c	99 b	99 c
Streamline	3.75	85 cd	100 b	100 c	100 b	100 c
Streamline	4.75	83 cd	100 b	100 c	100 b	100 c
Opensight	3	97 d	100 b	100 c	100 b	99 c
MAT28 Matrix	3.76 2	55 b	73 b	83 b	62 b	52 b
MAT28 Matrix	3.76 4	73 bc	77 b	88 bc	63 b	73 bc
MAT 240SL MSM	5.96 3.01	78 cd	99 b	98 bc	98 b	96 c
MAT 240SL MSM	7.52 3.84	83 cd	100 b	100 c	100 b	100 c
PDT Custom Blend	8	96 d	99 b	99 c	99 b	99 c
PDT Custom Blend Plateau	8 2	93 d	100 b	100 c	100 b	100 c
Millenium Ultra	32	96 d	100 b	100 c	100 b	100 c
Untreated	---	0 a	0 a	0 a	0 a	0 a

Table 3: Percent control of buckhorn plantain (*Plantago lanceolata*, PLALA). The trial was visually rated for percent control on August 10 (27 days after treatment, DAT) and November 3, 2011 (112 DAT), plus April 20 (281 DAT), May 16 (307 DAT), and June 27, 2012 (349 DAT). Treatments were applied on July 14, 2011. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Percent Control PLALA				
Product	Rate	27 DAT	112 DAT	281 DAT	307 DAT	349 DAT
	(oz/ac)					
Perspective	3.75	50 b	96 bc	93 b	97 b	97 b
Perspective	4.75	50 b	100 c	100 b	100 b	100 b
Streamline	3.75	50 b	100 c	100 b	100 b	99 b
Streamline	4.75	50 b	100 c	98 b	99 b	100 b
Opensight	3	50 b	99 bc	99 b	99 b	99 b
MAT28 Matrix	3.76 2	50 b	98 bc	98 b	98 b	95 b
MAT28 Matrix	3.76 4	50 b	93 b	95 b	97 b	95 b
MAT 240SL MSM	5.96 3.01	50 b	100 c	100 b	100 b	100 b
MAT 240SL MSM	7.52 3.84	50 b	100 c	100 b	100 b	99 b
PDT Custom Blend	8	75 c	100 c	100 b	100 b	100 b
PDT Custom Blend Plateau	8 2	58 bc	100 c	100 b	100 b	99 b
Millenium Ultra	32	50 b	100 c	100 b	99 b	99 b
Untreated	---	0 a	0 a	0 a	0 a	0 a

Table 4: Percent control of wild carrot (*Daucus carota*, DAUCA). The trial was visually rated for percent control on August 10 (27 days after treatment, DAT) and November 3, 2011 (112 DAT), plus April 20 (281 DAT), May 16 (307 DAT), and June 27, 2012 (349 DAT). Treatments were applied on July 14, 2011. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Percent Control DAUCA				
Product	Rate	27 DAT	112 DAT	281 DAT	307 DAT	349 DAT
	(oz/ac)					
Perspective	3.75	92 c	100 c	100 c	99 b	99 b
Perspective	4.75	88 c	100 c	99 c	98 b	97 b
Streamline	3.75	93 c	100 c	100 c	99 b	98 b
Streamline	4.75	85 c	98 c	97 c	83 b	99 b
Opensight	3	88 c	100 c	100 c	99 b	99 b
MAT28 Matrix	3.76 2	73 c	100 c	97 c	97 b	99 b
MAT28 Matrix	3.76 4	78 c	98 c	99 c	97 b	91 b
MAT 240SL MSM	5.96 3.01	88 c	100 c	100 c	100 b	98 b
MAT 240SL MSM	7.52 3.84	88 c	100 c	99 c	91 b	98 b
PDT Custom Blend	8	88 c	100 c	100 c	98 b	99 b
PDT Custom Blend Plateau	8 2	92 c	100 c	100 c	96 b	93 b
Millenium Ultra	32	35 b	42 b	45 bc	25 a	17 a
Untreated	---	0 a	0 a	0 a	0 a	0 a

EVALUATION OF TURF PHYTOTOXICITY CAUSED BY ESCORT XP, KRENITE S, AND MAT28

<u>Herbicide trade and common names</u>: Escort XP (*metsulfuron*), Krenite S (*fosamine*), MAT28 (*aminocyclopyrachlor*), PennDOT Custom Blend, Streamline (*aminocyclopyrachlor + metsulfuron*), Perspective (*aminocyclopyrachlor + chlorsulfuron*).

<u>Plant common and scientific names</u>: buckhorn plantain (*Plantago lanceolata*), fine fescue (*Festuca spp*.), Kentucky bluegrass (*Poa pratensis*), tall fescue (*Festuca arundinacea*), wild carrot (*Daucus carota*).

ABSTRACT

Controlling unwanted vegetation while preserving desirable groundcover, is an essential component of integrated vegetation management. On roadside areas, this is especially challenging because of the variety of hard to control weed and brush species that encroach on the right-of-way combined with the expectation of maintaining a healthy groundcover along the road. In some cases, herbicides that are effective at controlling the weeds and brush also damage the turf. MAT 28, Escort XP, and Krenite S are often used in weed and brush control applications. To better understand the phytotoxicity potential of these products, plots of mixed cool-season grasses were treated at various operational rates to measure the damage to common turfgrass species. Escort XP appeared to damage tall fescue at all rates tested in this experiment, while fine fescue and Kentucky bluegrass appeared more tolerant and only showed significant damage at rates of 1 oz/ac or greater. The damage caused by Krenite S and MAT28 was not significantly different than the untreated check plots.

INTRODUCTION

A successful broadleaf weed and woody vegetation control program that preserves the grass groundcover on the right-of-way is essential to maintain a safe and reliable roadway corridor. MAT28, Escort XP, and Krenite S are commonly used herbicides that are effective at controlling a host of broadleaf weed and brush species. However, Escort XP and Krenite S have both demonstrated the potential for damage to turf in past experiments.[1,2,3,4] MAT28 contains 50 percent *aminocyclopyrachlor* and is one of the active ingredients found in combination products such as Streamline, Perspective, and the PennDOT Custom Blend. Restrictions such as lower use rates and spring or fall treatments are found on these labels to safeguard against turf injury.[5,6] An experiment was conducted to examine the effects of these herbicides at various rates on a mixed stand of turf grass species.

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[1] Watschke T.L., et al. 1991. Response of Three Grass Species to Fall Applied Brush Control Treatments. Roadside Vegetation Management Research Report – Fifth Year Report. pp. 1-4.
[2] Gover, A.E. et al. 1993. Effect of Application Date on Response of Tall Fescue to Telar and Escort. Roadside Vegetation Management Research Report – Seventh Year Report. pp. 36-40.
[3] Gover, A.E. et al. 1993. Effect of Application Date on Response of Fine Fescues to Telar and Escort. Roadside Vegetation Management Research Report – Seventh Year Report. pp. 41-45.
[4] Johnson, J.M. et al. 2011. Evaluation of Aminocyclopyrachlor Tank Mixes Compared to Aminopyralid for Broadleaf Weed Control. Roadside Vegetation Management Research – 2011 Report. pp. 19-23.
[5] E. I. Dupont de Nemours and Company. 2011-2012. DuPont Perspective Herbicide. 12 pp.
[6] E. I. Dupont de Nemours and Company. 2011-2012. DuPont Streamline Herbicide. 14 pp.

MATERIALS AND METHODS

The experiment was conducted on an area of turf located at the Landscape Management Research Center of the Penn State University Park Campus, University Park, PA. The turf stand was composed of a mixture of species including tall fescue, fine fescue, and Kentucky blue grass. Plots were 6 by 13 feet in size and were arranged in a randomized complete block design with four replications. Weed species within plots included wild carrot and buckhorn plantain. The plots were irrigated as necessary to keep the turf actively growing prior to applying the treatments and through the subsequent evaluation.

The eleven treatments included MAT 28 at 2, 3.75, 6, and 7.5 oz/ac; Escort XP at 0.5, 1, 1.5, and 2 oz/ac; Krenite S at 128 and 192 oz/ac; and an untreated check. Cide Kick II surfactant was added to the Krenite treatments at 0.25% v/v, while all other treatments included CWC Surfactant 90 at 0.25% v/v. Treatments were applied on July 23, 2012 at 35 gal/ac and 37 psi using a CO_2 powered sprayer equipped with a 6-foot boom and four TeeJet 8004 nozzles. The site was visually rated for phytotoxicity to tall fescue and Kentucky bluegrass plus fine fescue on August 7, 2012, 15 days after treatment (DAT). A rating scale of 0 to 10 was used where "0" = no symptoms; "5" = moderate chlorosis, stunting; and "10" = complete necrosis, dead. Data were subjected to an analysis of variance and when treatment F-tests were significant ($p \leq 0.05$), Tukey's HSD test was used to separate the treatments into groups that are significantly different from one other.

RESULTS AND DISCUSSION

All herbicide treatments caused phytotoxicity symptoms at 15 days after treatment, DAT. Slight phytotoxicity values of 0.7 on tall fescue and 0.5 on a mixed stand of Kentucky bluegrass and fine fescue were assigned to the untreated check plots and were judged to be due to environmental stress rather than chemical phytotoxicity. The four rates of Escort XP produced phytotoxicity symptoms significantly higher than the untreated check on tall fescue ranging from 5.3 to 7.0 for rates of 0.5 to 2 oz/ac, repectively (Table 1). Among the mixed bluegrass and fine fescue plots, the lowest rate of 0.5 oz/ac Escort XP was not significantly different than the untreated check with a rating of 4.3; however, rates of 1, 1.5, and 2 oz/ac did result in significantly greater phytotoxicity symptoms compared to the untreated check with ratings ranging from 5.3 to 6.5. Rates of MAT28 from 2 to 7.5 oz/ac and Krenite S at 128 or 192 oz/ac did not produce phytoxicity symptoms significantly greater than the untreated check on tall fescue or the Kentucky bluegrass and fine fescue mix at 15 DAT. All treatment symptoms observed at 15 DAT were transient and were not visible by August 22, 2012, 30 DAT when viewed during the Roadside Vegetation Management Conference.

CONCLUSIONS

Escort XP caused notable injury to tall fescue at rates as low as 0.5 oz/ac while fine fescue and Kentucky bluegrass seemed somewhat more tolerant and displayed significant and observable symptoms at rates of 1 oz/ac and beyond. All the grass species seemed to tolerate the rates of MAT 28 and Krenite S tested in this experiment without damage significantly different from the untreated check plots.

MANAGEMENT IMPLICATIONS

It is apparent that exceeding rates of 0.5 oz/ac Escort XP should be avoided in order to preserve grass groundcovers during targeted broadleaf and brush applications. Escort XP rates below 0.5 oz/ac or alternate chemistry should be used where broadcast applications are implemented to control broadleaf weeds in turf and avoid injury and possible thinning of the turf stand. *Aminocyclopyrachlor* also known as MAT28 is one of the active ingredients in Streamline, Perspective, and the PennDOT Custom Blend labeled for broadleaf weed control applications in turf. Although MAT28 has demonstrated a margin of safety to common roadside cool-season grasses, the Escort XP or Telar components of these blends can cause injury and the products should be used at lower rates. An 8 oz rate of the PennDOT Custom Blend contains 0.33 oz Escort XP and 7.67 oz MAT28. This amount or less would provide a margin of safety to grasses. Perspective and Streamline contain MAT28 plus Telar and Escort, respectively. These labels not only caution against higher use rates but advise making applications in spring or fall during periods of aggressive turf growth. The herbicide Krenite S will not be a detriment to common grass species, but will impact the desirable broadleaf community within the understory during side-trimming operations so proper targeting is needed. Additional work with Escort XP as well as MAT28 and Krenite S on other sites and under various conditions may help refine the best rates to control brush and broadleaf weeds while preserving the turf groundcover.

Table 1. Phytotoxicity ratings for mixed turf plots treated with brush control herbicides. Plots were sprayed on July 23, 2012. Ratings were taken on August 7, 2012, 15 days after treatment. Each value is the mean of 4 replications. Within each column, means followed by the same letter are not significantly different at p≥0.05

Product	Rate	Phytotoxicity: Tall Fescue	Phytotoxicity: Kentucky Bluegrass and Fine Fescue
	(oz/ac)	(0-10 scale)	
untreated	---	0.7 a	0.5 a
MAT28	2	2.7 abcd	2.3 abc
MAT28	3.75	2.5 abc	4.0 abc
MAT28	6	2.7 abcd	3.3 abc
MAT28	7.5	3.8 abcd	4.3 abc
Escort XP	0.5	5.3 bcd	4.3 abc
Escort XP	1	7.0 d	5.3 bc
Escort XP	1.5	6.0 cd	6.5 c
Escort XP	2.0	7.0 d	5.8 bc
Krenite S	128	1.0 ab	1.3 ab
Krenite S	192	2.0 abc	2.3 abc

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

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

ABSTRACT

Rapid and successful establishment of vegetative cover is an important consideration for managers of roadside construction and renovation projects. Native ground covers, specifically warm season grasses (WSG), offer a potential alternative to crownvetch, which has been used extensively to provide cover for poor quality, low maintenance sites. In 2009, long-term replicated comparison experiment was initiated to determine the seasonal effects on establishment of Formula N, a native seed mix containing WSG and several legumes, to that of Formula C, a standard mix of crownvetch and annual ryegrass. Planting dates for the trial were February 13th, April 23rd, July 7th, and August 21st. Results from data collected in the fall of 2012 indicated that the February seeding of Formula N resulted in the greatest average number of switchgrass (0.8), and little bluestem (1.3) plants per sq. ft. In addition the February seeding produce the highest overall coverage rating at 40% for Formula N seeded plots. The April seeding of Formula N produced the greatest number of Indiangrass plants (0.8) per sq. ft. and the second greatest number of switchgrass (0.3) and little bluestem plants (0.8) per sq.ft. The February and April seedings produced an equivalent average stand of big bluestem plants (1.3) per sq. ft. Partridge pea and showy tick-trefoil, the legumes included in the Formula N mix, were evident in very low numbers and appeared only in one plot. For plots seeded to Formula C, the April seeding produced the highest percent cover of crownvetch (65%), followed by August (30%), July (4%), and February (3%). It appears that late winter through spring may be the best time to seed WSG mixtures, while crownvetch may establish best when seeded in spring or late summer.

INTRODUCTION

Reestablishment of groundcover on disturbed sites following road construction or during remediation is a major concern for project designers and managers. Crownvetch, the major component of Formula C, is capable of establishment on poor quality sites with infertile, compacted, or poorly drained soils and can be seeded at any time of year except September and October.[1] However, in 2000 it was listed as a "situational invasive" in the publication *Invasive Plants in Pennsylvania* by the Pennsylvania Department of Conservation and Natural Resources. Native warm-season grasses (WSG) provide a possible alternative to introduced species for revegetation of sites disturbed by road construction activities. One drawback is that WSG are

[1] PennDOT. Pub. 408 Specifications (2007), Section 804 – Seeding and Soil Supplement

slow and sometimes difficult to establish.[2] The purpose of this 2009 long-term experiment was to compare the establishment of native WSG species over four seeding dates spaced throughout the year to that of crownvetch. This report represents the fourth year of results following seeding.

MATERIALS AND METHODS

This experiment was established on a gently sloping site previously disturbed by road construction along I-99 northbound, west of State College, PA. The experiment utilized two seed mixes, Formula C (Table 1) and Formula N (Table 2), seeded during four planting periods: Nov to Feb, Mar to May, Jun to July, and Aug to Sep. Seeding occurred on February 13, April 23, July 7, and August 21, 2009. The eight treatments were applied to 20 by 24 ft. plots in a randomized complete block design with three replications. The 0.49 ac. site, was prepared by ripping the soil to loosen and reduce compaction and grading on October 16, 2008, followed by seeding cereal rye and straw mulch on October 22, 2008 to provide a winter vegetative cover. The site was amended with 46-0-0 urea, and 39-0-0 sulfur coated urea at a rate of 15 and 5.9 lbs per 1000 S.Y., respectively. At each seeding time, additional soil amendments were broadcast across the plots to be seeded. These amendments included pelletized limestone at 800 lbs per 1000 S.Y. and 20-10-10 fertilizer at 140 lbs per 1000 S.Y. Plots seeded to Formula N also received 39-0-0 sulfur-coated urea at 49 lb per 1000 S.Y. at seeding. Soil amendments were based on PennDOT Pub 408 specifications for seeding cool season grasses. All plots were straw mulched following seeding and soil amendment applications.

On July 18, 2012, all plots were mowed with a string trimmer at a height of approximately 12 inches to remove competition from broadleaf weeds, specifically sweet clover. On September 19, 2012, approximately 37 months after the last seeding, all plots were visually evaluated to estimate percent cover by crownvetch, percent total cover, and percent cover by WSG (only native seeded plots). Plots seeded with native mixes in February, April, and July produced enough WSG plants to warrant counts of individual species. Fixed subplot sampling, conducted on October 18, 2012, was used to count the WSG plants on 2% of the area within these plots. Subplots were located by establishing a single transect across the plot. A string was stretched diagonally between opposite corners of each plot. Subplots, two square feet in size, with a center point of 5’3”, 10’6”, 15’9”, 21’0”, 26’3” were set up along the transect line. Individual WSG plants within each subplot were identified and tallied. The mean number of plants per square foot for each species was calculated from data gathered within the five subplots. Quantitative data were subjected to analysis of variance. When treatment effect F-tests were significant ($p \leq 0.05$), means were compared using the Tukey HSD test.

RESULTS AND DISCUSSION

Cover ratings for Formula N plots are shown in Table 5. Plots seeded in February produced the highest percent cover by WSG (40%) followed by plots seeded in April (17%), July (2%), and August (0.2%). Stem counts for individual WSG species (Table 3) revealed that February and April seedings resulted in the greatest establishment. Plots seeded in February yielded the largest number of switchgrass and little bluestem plants, 0.8, and 1.3 plants per sq. ft., respectively. Big bluestem plants were found in equal numbers (1.3 stems per sq. ft.) in plots

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[2] Johnson, J.M. et al. 2012. Native Seed Mix Establishment Implementation – Year Four. Roadside Vegetation Management Research – 2012 Report, pp. 16-20.

seeded in February and April. April plots yielded the highest number of Indiangrass plants (0.8) per sq. ft. WSG stem counts were not calculated for plots seeded in August because there were not enough WSG plants present (0.2% cover) to warrant sampling.

Total vegetative cover ratings taken in 2012 for plots seeded to Formula N (Table 5) were similar for all 4 timings with the low being 65% in April and the high being 68% in July. When comparing percent cover by WSG between 2011 and 2012 growing seasons, the most striking difference was that the cover for the February seeding increased from 25% to 40%. Less obvious but also noteworthy was that the July seeding produced enough WSG plants to warrant fixed subplot sampling for the first time.

For plots seeded to crownvetch (Table 4), total cover ranged from a high of 88% for the April seeding to a low of 48% for the February seeding. Also for plots seeded to crownvetch, cover by crownvetch was highest for the April timing (65%), which was more than twice as high as the second highest rating of 30% for the August timing. A thorough description of the site and first and second full year results after seeding can be found at Johnson et al.[3,4,5]

CONCLUSIONS

From the data gathered at four years into the trial, following three full growing seasons, late winter through early spring appears to be the most favorable time to establish WSG cover. This corresponds with germination and growth expectations outlined by the Ernst Seeds company (www.ernstseeds.com) in that spring soil moisture conditions and soil temperatures of 55°F or greater provide for the greatest development.

July and August appear to be a poor time to seed sites with WSG mixes, although the plots seeded in July did show an increase in WSG stems during the 2012 growing season. This observation is in line with information from Ernst Seeds indicating that 20-50% of the seed may be dormant in a mix and that two to three full growing seasons are necessary for discernible development of seedlings due to the heavy investment by the seedling in root development over shoot growth. This trial has entered the window where greater visible presence of seedlings should be recorded, which was evident by the fact that for the first time in this research, the WSG plots seeded in July had produced enough WSG stems to warrant sampling.

The April and August seeding resulted in the greatest crownvetch establishment. This result appears reasonable since April environmental and soil conditions include warming temperatures and adequate soil moisture for the new developing seedlings. Similarly, late August often signals the start of cooler night temperatures and thus greater recovery time for seedlings and warm soil temperatures. Crownvetch remains a more rapid, expansive, and competitive ground cover on poor sites compared to WSG seeding. This is apparent in the coverage after seeding and in the competitive creep of crownvetch into WSG seeded sites. Reliance on WSG as a revegetation option requires a commitment to native mixes and a willingness to allow time and provide

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[3] 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.

[4] Johnson et al. 2011. Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Two. Roadside Vegetation Management Research Report – Twenty-fifth Year Report. pp. 59-63.

[5] Johnson et al. 2012. Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Three. Roadside Vegetation Management Research – 2012 Report. pp. 6-10.

management to assure establishment of the WSG seedlings as opposed to a quick fix with crownvetch.

MANAGEMENT IMPLICATIONS

More work needs to be done on establishment of WSG cover, but it appears that late winter through early spring may be the best time to seed. An intermediate cover crop may be necessary to provide cover until the WSG develop. In addition, temporary erosion control may have to be maintained during the extended establishment period. During the 2012 growing season, it became obvious that maintenance such as mowing, applying an herbicide, or both was necessary to keep the site from being overrun with broadleaf weeds and brush. This should be a planned component for any maintenance operation where Formula N will be established. This remains an ongoing experiment, in order to document consistent establishment rates for this mix. Consistent establishment is a necessary component of the success of Formula N and must be defined prior to operational use of the mix.

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. Stem counts for Plots seeded to warm season grasses (WSG). Seedings occurred February 13, April 23, July 7, and August 21, 2009. Data was recorded on October 18, 2012, approximately 37 months after the last seeding. Plots seeded in February, April, and July were sampled to establish the stem counts. Plots seeded in August had too few WSG stems to warrant sampling. Each value is the mean of three replications. Within each column, numbers followed by different letters are significantly different at the .05 level. Numbers in columns without letters are not significantly different from each other.

		Stems per Square Foot				
Treatment	Timing	Indiangrass	Big Bluestem	Switchgrass	VA Wildrye	Little Bluestem
Native	Feb	0.7	1.3 b	0.8 b	0	1.3 b
Native	Apr	0.8	1.3 b	0.3 a	0.5	0.8 ab
Native	Jul	0.1	0.1 a	0 a	0.5	0.1 a
Native	Aug	0	0 a	0 a	0	0 a

Table 4. Cover ratings for plots seeded to Formula C, crownvetch. Seedings occurred February 13, April 23, July 7, and August 21, 2009. Data was recorded approximately 37 months after the last seeding. Each value is the mean of three replications. Differences between means were considered statistically significant at p≤0.05. N.S. = not significant.

Treatment	Timing	% Cover by Crownvetch	% Total Cover
Crownvetch	February	3	48
Crownvetch	April	65	88
Crownvetch	July	4	73
Crownvetch	August	30	63
		N.S.	N.S.

Table 5 Comparison of cover ratings for plots seeded to Formula N warm season grasses (WSG). Data for 2011 was collected at approximately 25 months after the final seeding (August 2009), while data for 2012 was collected approximately 1 year later at 37 months from the last seeding. The crownvetch cover reported is based on volunteer plants emerging in the WSG plots. Percent cover was determined by visual observation. Within each column, numbers followed by different letters are significantly different at the .05 level. Numbers in columns without letters are not significantly different from each other.

		2011			2012		
Treatment	Timing	% Cover by Crownvetch	% Total Cover	% Cover by WSG	% Cover by Crownvetch	% Total Cover	% Cover by WSG
Native	Feb	1	68	25 a	0.7	67	40 b
Native	Apr	8	72	20 ab	2.6	65	17 a
Native	Jul	28	87	1 b	23.0	68	2 a
Native	Aug	2	73	1 b	2.0	67	0.2 a

EVALUATION OF INDAZIFLAM, PENDIMETHALIN, AND PRODIAMINE IN TANK MIXES FOR BAREGROUND WEED CONTROL

Herbicide trade and common names: Diuron (*diuron*), Escort (*metsulfuron*), Esplanade (*indaziflam*), Frequency (*topramezone*), MAT28 50SG (*aminocyclopyrachlor*), Milestone (*aminopyralid*), Oust Extra (*sulfometuron + metsulfuron*), Pendulum AquaCap (*pendimethalin*), Proclipse (*prodiamine*), Roundup Power Max (*glyphosate*), Streamline, PDT Blend (*aminocyclopyraclor + metsulfuron*).

Plant common and scientific names: barnyardgrass (*Echinochloa crus-galli*, ECHCG), bedstraw (*Galium aparine*, GALAP), broadleaf plantain (*Plantago major*, PLAMA), coltsfoot (*Tussilago farfara*, TUSFA), common ragweed (*Ambrosia artemisiifolia*, AMBAR), fall panicum (*Panicum dichotomiflorum*, PANDI), foxtail spp. (*Setaria* spp., SETXX), marestail (*Conyza canadensis*, ERICA), mouseear chickweed (*Cerastium fontanum* ssp. *vulgare*, CERVU), orchardgrass (*Dactylis glomerata*, DACGL), red clover (*Trifolium pratense*, TRIPR), smooth crabgrass (*Digitaria ischaemum*, DIGIS), speedwell (*Veronica* ssp., VERXX), wild carrot (*Daucus carota*, DAUCA), witchgrass (*Panicum capillare*, PANCA).

ABSTRACT

Maintaining weed-free areas under guiderails, around signposts, and in storage yards is an important consideration for vegetation managers. The benefits of keeping these areas free from vegetation include maintaining sight-distance, allowing access, ensuring proper drainage, increasing aesthetics, and reducing maintenance costs. Herbicide tank mixes are often used to eliminate existing weeds and prevent the establishment of new vegetation. Bayer Environmental Science recently developed a new active ingredient, *indaziflam*, labeled as "Esplanade" for bare ground vegetation management. Previous experiments have shown *indaziflam* to be an effective preemergence herbicide in controlling a host of unwanted plant species. The present experiment tested indaziflam in combination with broad-spectrum residual herbicides to evaluate indaziflam in comparison with pendimethalin and prodiamine for use in season-long bareground weed control. Experiments were conducted at two locations with varying weed pressure. Overall indaziflam, pendimethalin, and prodiamine provided season-long bareground control at both sites using the tank mixes and rates tested in this trial.

INTRODUCTION

The areas beneath guiderails, around mowing obstacles (e.g., signposts), or within gravel storage yards are often treated with herbicides to keep them weed-free. The benefits of keeping bare ground in these areas include maintaining sight-distance, facilitating access, improving drainage, enhancing aesthetics, and reducing maintenance costs. Many herbicide tank mixes are currently available to provide control of unwanted vegetation in these areas. However, new tank-mix partners continue to be available for testing to provide better late-season control of germinating annuals and to prevent the development of resistant species. A new active ingredient, *indaziflam*, trade name "Esplanade" has demonstrated excellent total vegetation control and may serve as an effective alternative to other preemergence herbicides in a bareground weed control program.[1,2,3] In this experiment, Esplanade was combined with broad-spectrum residual herbicides to establish its effectiveness at providing season-long control. Additionally, the preemergence products Pendulum that has shown promise in past experiments and Proclipse were compared to Esplanade for bareground applications.[3]

MATERIALS AND METHODS

Two trial sites were established under guiderails to evaluate season-long bareground weed control. The first site was located along Dix Run Rd (SR330) near Julian, PA while the second site was along Frankstown Rd, near Altoona, PA. The experiment consisted of 14 treatments including glyphosate alone at 64 oz/ac; Esplanade at 3.5 or 5 oz/ac combined with Milestone at 7 oz/ac and Escort at 1 oz/ac; Esplanade alone at 5 oz/ac or mixed with Frequency at 4 oz/ac, Streamline at 7.5 oz/ac, PDT Blend at 8 oz/ac, or Oust Extra at 4 oz/ac; ProClipse at 36.8 oz/ac or Pendulum AquaCap at 134 oz/ac plus PDT Blend at 8 oz/ac or Oust Extra at 4 oz/ac; Diuron at 128 oz/ac plus Oust Extra at 4 oz/ac; and an untreated check. All treatments included Roundup Power Max at 64 oz/ac and CWC Surfactant 90, a non-ionic surfactant, at 0.25% v/v. The treatments were applied to 5 by 20 ft plots with four replications at each location. The carrier volume was 50 gal/ac. Treatments were applied on May 1 and April 25, 2012, at Dix Run Rd. and Frankstown Rd., respectively. Equipment used in applying treatments included a CO_2-powered backpack sprayer equipped with an ultra low volume wand and Spraying Systems Boomjet XP25L spray tip. The first notable rainfall occurred thirteen days following treatment at Dix Run Rd. and one day after treatment at Frankstown Rd. with total amounts of 0.41 and 0.22 inches, respectively.

The Dix Run Rd. trial was evaluated for percent bareground (Table 1) and percent cover by wild carrot, red clover, broadleaf plantain, and coltsfoot on June 4, July 6, August 13, September 5, and October 12, 2012, 34, 66, 104, 127, and 164 DAT. Additionally, percent cover by common ragweed was rated July 6, August 13, September 5, and October 12, 2012 while cover by annual grasses (i.e., foxtail spp, barnyardgrass, fall panicum, smooth crabgrass, and witchgrass) was evaluated August 13, September 5, and October 12, 2012.

The Frankstown Rd. trial was visually rated for percent bareground (Table 2) plus percent cover by orchardgrass, bedstraw, mouseear chickweed, and speedwell on May 25 and June 25, 2012, 30 and 61 DAT. The preceeding evaluations plus cover by marestail and annual grasses (i.e., smooth crabgrass, foxtail spp., witchgrass, and barnyardgrass) were rated July 26, September 28 and October 26, 2012, which corresponds to 92, 156, and 184 days after treatment, DAT. Replications 3 and 4 were inadvertently sprayed by contract spray crews between the June 25 and July 26 rating, so beginning July 26th they were no longer evaluated.

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[1] Johnson, J.M. et al. 2010. Indaziflam/AE1170437 for Bareground and Suppression of Kochia. Roadside Vegetation Management Research – 2010 Report. pp. 26-29.
[2] Johnson, J.M., Despot, D.A., and Sellmer, J.C. 2012. Indaziflam as a Preemergence Component in a Bareground Weed Control Program. Roadside Vegetation Management Research – 2012 Report. pp. 24-27.
[3] Johnson, J.M., Despot, D.A., and Sellmer, J.C. 2012. MAT28 in Combination with Preemergence Herbicides for Season-Long Bareground Weed Control. Roadside Vegetation Management Research – 2012 Report. pp. 28-32.

RESULTS AND DISCUSSION

The weed pressure at both sites was low during the summer of 2012. At Dix Run Rd. all herbicide treatments including Roundup alone provided excellent and similar control by keeping all bareground ratings above 97 percent, except Roundup alone at 127 DAT (96.75%). Untreated plots averaged from 86.25 to 66.25 percent bareground throughout the season. No weed species developed in enough quantity to demonstrate a lack of control by the herbicide treatments. All herbicide treatments provided similar and almost complete control, extrapolated from percent cover ratings taken throughout the season. The Frankstown Rd. trial site provided greater weed pressure, but the elimination of two reps midway through the season reduced the strength of the findings; however, all herbicide treatments remained statistically similar. All herbicide treatments maintained bareground levels at 97 percent or above, except for Roundup alone (93.50 to 94%), Pendulum AquaCap plus PDT Blend (93.50 to 96.50%), and diuron plus Oust Extra (95 to 96%) during the last three ratings. The only species that produced significantly higher cover throughout the evaluation period were orchardgrass, marestail, and annual grasses (combined). Orchardgrass developed into significant populations where Roundup alone (1% at 184 DAT) and Pendulum AquaCap plus PDT Blend (3% at 156 DAT and 2% at 184 DAT) were applied. Higher cover ratings of 1.5% for marestail were observed where Proclipse plus Oust Extra at 92 DAT and 0.5% for Roundup alone and diuron plus Oust Extra treatments at 184 DAT were applied. Annual grasses emerged to provide significantly more cover at 2.5% in the Roundup only treatments at 92 DAT.

CONCLUSION

Neither site produced an overwhelming amount of vegetation during the course of this experiment. However, both *indaziflam* (Esplanade) and *pendimethalin* (Pendulum) continued to perform well in providing season-long control in bareground situations. These results add to the body of evidence accumulated over the past three years regarding the effectiveness of these products as tank-mix partners for total vegetation control. Additionally, the preemergence herbicide Proclipse performed well enough to be considered as a component in bareground tank mixes. Continued investigation of these products with assorted rates, common tank mix partners, on a variety of sites, and for a host of target species will help to identify the weaknesses and strengths of these materials.

MANAGEMENT IMPLICATIONS

Esplanade and Pendulum AquaCap are products well suited as tank-mix partners for bareground applications. Esplanade should be used at rates of 5-7 oz/ac and Pendulum AquaCap at 134 oz/ac plus tank mixed with broadspectrum residual herbicides, e.g., *sulfometuron* (Oust Extra), *aminopyralid* (Milestone), or *aminocyclopyrachlor* (Streamline, PDT Blend), to ensure season-long weed control. Pendulum AquaCap will produce some short-term staining and prudence should be observed where this is objectionable.

Table 1. Percent bareground after application of combinations of preemergence and broad spectrum weed control products at the Dix Run Rd. (SR330) trial site near Julian, PA. Treatments were applied May 1, 2012. Evaluations were conducted on June 4 (34 days after treatment, DAT), July 6 (66 DAT), August 13 (104 DAT), September 5 (127 DAT), and October 12, 2012 (164 DAT). Values are the mean of 4 replications. Column means followed by the same letter are not significantly different at p≤0.05.

		Percent Bareground				
Treatment	Rate	34 DAT	66 DAT	104 DAT	127 DAT	164 DAT
	(oz/ac)					
Untreated	---	81.25 b	76.25 b	68.75 b	66.25 b	86.25 b
Roundup	64	98.50 a	99.25 a	97.25 a	96.75 a	97.50 a
Esplanade	5	99.50 a	99.75 a	99.25 a	98.25 a	98.75 a
Esplanade Milestone Escort XP	3.5 7 1	100 a	100 a	99.50 a	99.25 a	99 a
Esplanade Milestone Escort XP	5 7 1	100 a	100 a	100 a	100 a	100 a
Esplanade Frequency	5 4	99.75 a	100 a	99.75 a	99.75 a	99.75 a
Esplanade Streamline	5 7.5	100 a	100 a	100 a	100 a	100 a
Esplanade PDT Blend*	5 8	99.75 a	100 a	100 a	100 a	100 a
Esplanade Oust Extra	5 4	100 a	99.75 a	99.75 a	99.50 a	100 a
Proclipse PDT Blend*	36.8 8	100 a	100 a	100 a	99.25 a	99.75 a
Proclipse Oust Extra	36.8 4	99 a	100 a	100 a	99.50 a	99.50 a
Pendulum AquaCap PDT Blend*	134 8	100 a	99.75 a	99.75 a	99.25 a	99 a
Pendulum AquaCap Oust Extra	134 4	98.75 a	100 a	99.50 a	99.25 a	99.25 a
Diuron Oust Extra	128 4	98.25 a	100 a	99.50 a	99.25 a	99.50 a

* 8 oz PDT Blend = 7.67 oz MAT28 (50% a.i. *aminocyclopyrachlor*) + 0.33 oz Escort XP.

Table 2. Percent bareground after application of combinations of preemergence and broad spectrum weed control products at the Frankstown Rd. trial site near Altoona, PA. Treatments were applied April 25, 2012. Evaluations were conducted on May 25 (30 days after treatment, DAT), June 25 (61 DAT), July 26 (92 DAT), September 28 (156 DAT), and October 26, 2012 (184 DAT). Values are the mean of 4 replications up to 61 DAT. Only 2 replications remained for future evaluations. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Percent Bareground				
Treatment	Rate	30 DAT	61 DAT	92 DAT	156 DAT	184 DAT
	(oz/ac)					
Untreated	---	83.75 b	79.75 b	77.50 b	70 b	70 b
Roundup	64	99.50 a	98.00 a	94.00 a	93.50 a	93.50 a
Esplanade	5	99.50 a	100 a	99.50 a	99.50 a	99.50 a
Esplanade Milestone Escort XP	3.5 7 1	100 a	100 a	100 a	100 a	100 a
Esplanade Milestone Escort XP	5 7 1	100 a	100 a	99.50 a	99.50 a	99 a
Esplanade Frequency	5 4	99.75 a	100 a	100 a	99.50 a	99.50 a
Esplanade Streamline	5 7.5	100 a	100 a	100 a	100 a	100 a
Esplanade PDT Blend*	5 8	100 a	100 a	100 a	99.50 a	99.50 a
Esplanade Oust Extra	5 4	100 a	100 a	100 a	100 a	100 a
Proclipse PDT Blend*	36.8 8	100 a	100 a	97.50 a	97 a	97.50 a
Proclipse Oust Extra	36.8 4	100 a	100 a	98.50 a	98 a	98.50 a
Pendulum AquaCap PDT Blend*	134 8	100 a	99.75 a	96.50 a	93.50 a	94.50 a
Pendulum AquaCap Oust Extra	134 4	99.75 a	100 a	98.00 a	97.50 a	98 a
Diuron Oust Extra	128 4	99.00 a	99.75 a	95.50 a	95 a	96 a

8 oz PDT Blend = 7.67 oz MAT28 (50% a.i. *aminocyclopyrachlor*) + 0.33 oz Escort XP.

OPTIONS FOR POSTEMERGENCE KOCHIA AND MARESTAIL CONTROL

<u>Herbicide trade and common names:</u> Arsenal (*imazapyr*), DMA 4 IVM (*2,4-D*), Escort XP (*metsulfuron*), Garlon 3A (*triclopyr*), Roundup Pro Concentrate (*glyphosate*), MAT28 (*aminocyclopyrachlor*), Milestone VM (*aminopyralid*), Oust Extra (*sulfometuron* + *metsulfuron*), Overdrive (*dicamba* + *diflufenzopyr*), Panoramic (*imazapic*), Telar XP (*chlorsulfuron*), Transline (*clopyralid*), Vanquish (*dicamba*), Velpar DF (*hexazinone*), Vista (*fluroxypyr*).
<u>Plant common and scientific names:</u> kochia (*Kochia scoparia*), marestail (*Conyza canadensis*).

ABSTRACT

Kochia and marestail readily germinate in dry, shallow soils, which make them strong competitors for resources in bare ground settings. Their long germination period, prolific seed production, effective seed dispersal, and ability to develop herbicide resistance contribute to the severity of their invasive character. For plants that elude preemergent herbicide treatments in bareground settings, postemergent treatment is required. Fourteen herbicides were tested for post emergence control of kochia and marestail on a guiderail setting along SR322 near State College, PA. Vanquish and Vista provided the best control of kochia at 86% and 81%, respectively. Velpar DF and MAT28 were most effective in controlling marestail with 99% and 94%, respectively. The results of this experiment demonstrate that one product will not provide effective control for both weed problems in a bareground situation. We recommend that vegetation manager consider their product rotation options and plan tank mixes of the most effective products to control both of these problem invasive weeds.

INTRODUCTION

Kochia is an annual and marestail can be an annual or short-lived biennial plant. Both species present similar challenges for right-of-way vegetation managers in bareground weed control situations because of three shared characteristics: a long germination period which continues well beyond the initial spring growth, resistance to several classes of herbicides (e.g., ALS inhibitors, synthetic auxins, and photosynthetic inhibitors), and heavy seed production combined with effective dispersal. If any of the plants escape the initial bareground herbicide application they can rapidly grow and exploit the otherwise vegetation free area. Once they grow beyond the seedling stage, control with postemergence herbicides becomes more difficult.[1] The objective of this experiment was to compare fourteen postemergence herbicides for control of kochia and marestail.

MATERIALS AND METHODS

The trial was established in the median of SR 322 east at the SR 26 overpass near State College, PA. Plots of 6 by 20 feet in size were located from the edge of the pavement to the front of the guiderail posts and were arranged in a randomized complete block design with four replications. The treatments included an untreated check and the following fourteen post

[1] Johnson et al. 2009. Options For Postemergence Kochia Control. Roadside Vegetation Management Research – 2009 Report. pp. 34-39.

emergence herbicides (in oz/ac): Roundup Pro Concentrate at 52, DMA 4 at 64, Vista at 32, Vanquish at 24, Overdrive at 8, Garlon 3A at 48, Milestone VM at 6, Transline at 8, Escort XP at 2, Oust Extra at 4, Arsenal at 16, Velpar DF at 20, Panoramic at 12, and MAT28, at 7.5. A non-ionic surfactant was added to all treatments at 0.25% v/v. Treatments were applied on July 12, 2012 in a carrier volume of 50 gal/ac with a CO_2 powered backpack sprayer at 35 psi using a 6-foot boom equipped with four 8004VS nozzles. At the time of treatment, kochia and marestail plants measured on average 6 and 18 inches in height, respectively.

The trials were visually rated for percent total vegetation cover and individual cover by kochia and marestail at the time of treatment. On August 24, 2012, 43 days after treatment (DAT), the plots were rated for percent control of kochia and marestail. Results were subjected to ANOVA and when treatment effect F-tests were significant ($p \leq 0.05$), means were compared using Tukeys HSD test.

RESULTS AND DISCUSSION

For kochia at 43 DAT, two products performed significantly better than the others for control (Table 1) with Vista at 32 oz/ac showing 81% and Vanquish at 24 oz/ac showing 86% control. All other treatments showed moderate control rates with MAT 28 at 7.5 oz/ac at 55% and Overdrive at 8 oz/ac at 50%. Roundup Pro Concentrate at 52 oz/ac provided less than 20% control. The most effective treatments on marestail were Velpar DF at 20 oz/ac with 99% and MAT 28 at 7.5 oz/ac with 94% control. Milestone VM at 6 oz/ac provided 50% control, while Vanquish at 24 oz/ac, Overdrive at 8 oz/ac, and Garlon 3A at 48 oz/ac each delivered 38% control. All other treatments provided less than 32% control.

CONCLUSIONS

Kochia and marestail appear to respond quite differently to herbicides used for postemergence weed control. In this trial, Vista and Vanquish worked best on kochia, while marestail was most effectively controlled with Velpar DF and MAT 28.

MANAGEMENT IMPLICATIONS

Current rotation options for postemergent control of kochia include Vista or Vanquish. For marestail, the options for postemergence chemistry include Velpar DF or MAT28. MAT28, or *aminocyclopyrachlor*, is commercially available in several premix combinations for bareground weed control including Perspective (*MAT28 + Telar XP*), Streamline (*MAT28 +Escort XP*), Viewpoint (*MAT28 +Arsenal + Escort XP*), and the PennDOT Custom Blend (a specialty mix of *MAT28 + Escort XP*).

Table 1. Visual ratings of total vegetative cover and cover by kochia and marestail at the time of treatment, July 12, 2012, as well as visual ratings of % control of kochia and marestail on August 24, 2012, 43 DAT. The trial was conducted in the median of SR322 east at the SR 26 overpass near State College, PA. Numbers represent the mean of 4 replications. Within each column, numbers followed by the same letter are not significantly different from each other at $p \leq 0.05$.

Treatment	Rate	Initial % Total Cover	Initial % Cover Kochia	Initial % Cover Marestail	43 DAT % Control Kochia	43 DAT % Control Marestail
	(oz/ac)					
Untreated	---	10	6	4	0 a	0 a
Roundup Pro Conc.	52	8	3	4	19 ab	31 bcd
DMA 4	64	8	3	5	19 ab	31 bcd
Vista	32	10	5	5	81 c	28 bcd
Vanquish	24	8	4	4	86 c	38 cd
Overdrive	8	9	6	3	50 bc	38 cd
Garlon 3A	48	8	2	4	19 ab	38 cd
Milestone VM	6	9	3	5	6 a	50 d
Transline	8	8	5	3	0 a	31 bcd
Escort XP	2	8	4	5	0 a	21 abc
Oust Extra	4	10	5	4	3 a	10 ab
Arsenal	16	8	3	4	0 a	0 a
Velpar DF	20	8	3	4	3 a	99 e
Panoramic	12	8	3	4	0 a	0 a
MAT28	7.5	9	4	4	55 bc	94 e
		N.S.	N.S.	N.S.		