Roadside Vegetation Management Research – 2015 Report

ANNUAL REPORT

June 30, 2015

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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: 2012 Investigation of Morrow's Honeysuckle (*Lonicera morrowii*) Control with Herbicide Tank Mix Combinations, Investigation of Herbicide Tank Mixes Using Increased Rates of 2,4-D for Control of Morrow's Honeysuckle (*Lonicera morrowii*), Evaluation of the Herbicides Streamline® and Viewpoint® for Control of Black Birch (*Betula lenta*) – Second Year Results, Comparing Foliar Applied Aminocyclopyrachlor Products to Older Brush Control Materials in Controlling Resprouting Brush After Mowing – Second Year Results, Comparison of Herbicide and Mowing Regimes for Control of Canada Thistle in a Grass Groundcover, Conversion of Canada Thistle Infested Crownvetch Groundcover to Fine Fescue Turf – Second Year Results, Comparison of Plateau and Panoramic Tank Mixes for Turf Growth Regulation and Broadleaf Weed Control, Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Five, Investigating Grass Species, Seeding Rates, and Fertilizer Plus Broadleaf Herbicide Application for Groundcover Establishment in Roadside Applications, Comparing Esplanade Bareground Tank Mixes with Plateau for Season-Long-Weed Control.			
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INTRODUCTION

In October 1985, personnel at Penn State began a cooperative research project with the Pennsylvania Department of Transportation (PennDOT) to investigate several aspects of roadside vegetation management. An annual report has been submitted each year 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

Report # PA-2013-008-PSU RVM Roadside Vegetation Management Research
– 2013 Report

Report # PA-2014-009-PSU RVM Roadside Vegetation Management Research
– 2014 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, ME=microencapsulated, RTU = ready to use, S=water soluble, SC = soluble concentrate, SG = soluble granule, SL = soluble liquid, WG, WDG=water-dispersible granules.

Trade Name	Active Ingredients	Formulation	Manufacturer
Accord XRT II	glyphosate	5.07 S	Dow AgroSciences LLC
Aquasweep	2,4-D + triclopyr	34.2 + 15.2 S	Nufarm Americas Inc.
Arsenal	imazapyr	2 S	BASF Corporation
Derigo	foramsulfuron + iodosulfuron thiencarbazone	36.4 WDG	Bayer Environmental Science
Diuron 80	diuron	80 WDG	Drexel Chemical Company
DMA 4 IVM	2,4-D	3.8 S	Dow AgroSciences LLC
Embark	mefluidide	2S	PBI/Gordon Corporation
Escort XP	metsulfuron methyl	60 WDG	E.I. DuPont de Nemours & Co.
Esplanade	indaziflam	200 SC	Bayer Environmental Science
Garlon 3A	triclopyr amine	3 S	Dow AgroSciences LLC
Garlon 4	triclopyr ester	4 EC	Dow AgroSciences LLC
Imazapyr	imazapyr	75 WG	E.I. DuPont de Nemours & Co.
Journey	glyphosate + imazapic	1.5 + 0.75 S	BASF Corporation
Krenite S	fosamine	4 S	E.I. DuPont de Nemours & Co.
Lesco Three Way	2,4-D + mecoprop-p + dicamba	3.23S	LESCO, Inc.
MAT28, Method 50SG	aminocyclopyrachlor	50 WDG	E.I. DuPont de Nemours & Co.
Matrix	rimsulfuron	25 SG	E.I. DuPont de Nemours & Co.
Milestone VM	aminopyralid	2 S	Dow AgroSciences LLC
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.
Oust XP	sulfometuron	75 DG	E.I. Dupont de Nemours & Co.
Overdrive	dicamba + diflufenzopyr	55 + 21.4 WDG	BASF Corporation
Panoramic	imazapic	2SL	Alligare LLC
PennDOT Blend (or PDT Custom Blend)	aminocyclopyrachlor + metsulfuron	47.9 + 2.5 DF	E.I. DuPont de Nemours & Co.
Perspective	aminocyclopyrachlor + chlorsulfuron	39.5 + 15.8 DF	E.I. DuPont de Nemours & Co.
Plateau	imazapic	2SL	BASF Corporation
Razor Pro	glyphosate	4 S	NuFarm Americas Inc.
Roundup Original Max	glyphosate	5.5 S	Monsanto Company
Roundup Pro Concentrate	glyphosate	5 S	Monsanto Company
Stalker	imazapyr	2 S	BASF Corporation
Streamline	aminocyclopyrachlor + metsulfuron	39.5 + 12.6 DF	E.I. DuPont de Nemours & Co.
Tordon K	picloram	2 S	Dow AgroSciences LLC
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.
Viewpoint	aminocyclopyrachlor + metsulfuron + imazapyr	22.8 + 7.3 + 31.6 DF	E.I. DuPont de Nemours & Co.
Weedar 64	2,4-D	3.8 S	NuFarm Inc.

2012 INVESTIGATION OF MORROW'S HONEYSUCKLE (LONICERA MORROWII) CONTROL WITH HERBICIDE TANK MIX COMBINATIONS

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*), smooth brome (*Bromus inermis*), 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 above-mentioned active ingredients for control of this species and the impact to the understory. Herbicide mixes containing glyphosate or 2,4-D resulted in the best control of Morrow's honeysuckle with 83 to 99 percent control at one year after treatment. A slight decline in control was observed at two years after treatment for most of the herbicide mixes tested. Treatments containing glyphosate or 2,4-D continued to provide the greatest control from 65 to 98 percent. 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 had the greatest 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 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. The result of relying on ineffectual herbicide mixes has been an expansion of existing stands along many corridors. Glyphosate has been an effective herbicide for control of 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 forms were tested in this experiment, including 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 plot on controlling shrub honeysuckle was included. This experiment was designed to determine and compare the efficacy of these products in combination with other herbicides for foliar application to control 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.

Morrow's honeysuckle and the grass/forb understory was rated based on percent injury (0 = no injury, 100 = complete necrosis) on August 9, 2012, 30 days after treatment, DAT. Furthermore, Morrow's honeysuckle was rated based on percent control (based on percent canopy loss) at one and two years after treatment (YAT) on June 27, 2013 and July 9, 2014, respectively. 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

Initial injury to Morrow's honeysuckle ranged from 29 to 96 percent for the herbicide treatments at 30 days after treatment, DAT. Treatments containing 2,4-D or Roundup Pro Concentrate resulted in 94 to 96 percent injury. All other treatments that included either aminocyclopyrachlor (PennDOT Blend or Streamline) or aminopyralid (Milestone VM or Opensight) resulted in injury values of 29 to 54 percent.

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

One year after treatment, YAT, the same trends continued across the herbicide treatments. Control of Morrow's honeysuckle ranged from 19 to 99 percent. Treatments containing 2,4-D or Roundup Pro Concentrate provided 83 to 99 percent control. These treatments included Garlon 3A plus 2,4-D or Roundup Pro Conc.; Roundup Pro Conc. alone; and Aquasweep plus Escort XP. The Aquasweep plus Escort XP combination resulted in the lowest mean control rating among the treatments (i.e., 83 percent); however, one plot demonstrated uncharacteristically poor control (60 percent) while other plots were rated 90, 95, and 80 percent. In plots with treatments containing 2,4-D or Aquasweep, some sprouting was observed at the base of Morrow's honeysuckle plants. All other herbicide treatments continued to offer poor to mediocre control with values from 19 to 51 percent.

By 2 YAT, a slight decline in Morrow's honeysuckle control was observed for most treatments. However, treatments containing 2,4-D or Roundup Pro Conc. continued to provide the greatest control from 65 to 98 percent while all other treatments ranged from 18 to 49 percent control.

The grass understory was comprised predominantly of smooth brome; however, the injury ratings were taken collectively for all grass species present. The most dramatic injury to these 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 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 produced similar injury to the forb understory and ranged from 62 to 99 percent.

CONCLUSIONS

Tank mixes of Garlon 3A plus 2,4-D or Roundup Pro Conc.; Roundup Pro Conc. alone; and Aquasweep plus Escort XP at the rates tested caused nearly complete defoliation of Morrow's honeysuckle. Sprouting from the base of the Morrow's honeysuckle shrubs can be expected using 2,4-D or Aquasweep following a single application. Herbicide treatments containing aminocyclopyrachlor (e.g., PennDOT Blend or Streamline) or aminopyralid (e.g., Milestone VM or Opensight) at the rates evaluated provided only marginal control of Morrow's honeysuckle. Carrier volume is critical to achieving control[5] and 50 gallons per acre seemed sufficient for control with the most effective treatments.

The observed understory damage demonstrated that tank mixes that included 8 oz/ac PennDOT Blend or 4 oz/ac PennDOT Blend with 0.5 oz/ac Escort XP and treatments containing Roundup Pro Conc. had a significant impact on the grass (mainly smooth brome) understory. Forbs that were over sprayed were equally damaged by all of the treatments.

Further testing of 2,4-D and Aquasweep in progressive rates and within label guidelines in combination with other herbicides was implemented in 2013 and early evaluations are reported later in this Annual Report.[6]

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[5] Gover et al. 2008. Grass-safe Herbicide Mixes for Woody Vegetation Control - *ongoing*. Roadside Vegetation Management Research – 2008 Report. pp. 3-6.

[6] Johnson et al. 2015. Investigation of Herbicide Tank Mixes Using Increased Rates of 2,4-D for Control of Morrow's Honeysuckle (Lonicera Morrowii). Roadside Vegetation Management Research – 2015 Report. pp. 6-9.

MANAGEMENT IMPLICATIONS

Tank mixes that include 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D or 96 oz/ac Aquasweep plus 0.5 oz/ac Escort XP offer an opportunity to control Morrow's honeysuckle in carrier volumes of 50 gal/ac. Subsequent treatments would be required within one or two seasons to address sprouting from the base and improve control of the targeted shrubs. Increased rates of 2,4-D or Aquasweep should be investigated to determine whether enhanced control can be achieved. Though these mixes will result in injury to both the grass and forb understory, the impact is not completely devastating to the grasses and is transient for many grass species.

Roundup Pro Concentrate produced the highest level of control on Morrow's honeysuckle at both 1 and 2 years after treatment. With careful use, this and other glyphosate products may be an option for control of Morrow's honeysuckle on the roadside if the application specifically targets honeysuckle plants. While the understory is killed by contact with glyphosate, there is no residual activity in the soil, allowing vegetation to regrow from the existing soil seedbank. Herbicides with residual activity in the soil may inhibit understory vegetation from regrowing for some time, depending on the product and the rate applied.

Table 1. Percent injury and control of morrow's honeysuckle (*Lonicera morrowii*, LONMO) plus injury to the grass and forb understory. The trial was visually rated for percent injury on August 9, 2012 (30 days after treatment, DAT) and percent control of LONMO on June 27, 2013 (1 year after treatment, YAT) and July 9, 2014 (2 YAT). 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 ≤ 0.05.

		Percent Injury (30 DAT)			Percent Control LONMO	
product	rate	LONMO	Grasses	Forbs	1 YAT	2 YAT
	(oz/ac)					
untreated	---	0 a	0 a	0 a	0 a	0 a
PennDOT Blend	8	29 b	54 b-e	67 b	41 bc	40 a-d
PennDOT Blend Escort XP	8 0.25	42 b	87 cde	95 b	43 bc	39 a-d
Garlon 3A PennDOT Blend Escort XP	64 4 0.5	50 b	67 cde	84 b	31 abc	26 abc
Garlon 3A Vanquish Milestone VM	32 32 7	54 b	44 abc	62 b	51 cd	49 b-e
Garlon 3A Streamline	64 2.5	42 b	52 bcd	84 b	26 abc	27 abc
Garlon 3A Opensight	64 3.3	49 b	46 abc	80 b	19 ab	18 ab
Garlon 3A 2,4-D	64 64	94 c	50 bc	86 b	89 e	72 def
Garlon 3A Roundup Pro Conc.	64 104	95 c	97 de	99 b	97 e	88 ef
Roundup Pro Conc.	104	95 c	100 e	99 b	99 e	98 f
Aquasweep Escort XP	96 0.5	96 c	19 ab	67 b	83 de	65 c-f

INVESTIGATION OF HERBICIDE TANK MIXES USING INCREASED RATES OF 2,4-D 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*); PennDOT Blend (*aminocyclopyrachlor + metsulfuron*); 2,4-D, DMA 4 IVM, Weedar 64 (*2,4-D*).

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

ABSTRACT

The proliferation of exotic shrub honeysuckle species including tatarian, amur, and Morrow's honeysuckle has become a common problem along the roads of Pennsylvania. Exotic shrub honeysuckle as with other woody species invading transit corridors, need to be controlled because they limit sight distance and interfere with highway maintenance activities. We have observed that herbicide tank mixes commonly used as foliar sprays to manage other encroaching tree and shrub species are often ineffective at controlling the exotic shrub honeysuckles. Glyphosate has been effective, however, it readily damages the understory. Control of Morrow's honeysuckle was achieved in a previous trial using 2,4-D. The goal of this experiment was to use progressive rates of 2,4-D and identify grass safe herbicide tank mix partners that are effective at controlling Morrow's honeysuckle while offering the potential to control a broad spectrum of other woody species. A total of eight herbicide combinations were tested. All treatments containing 96 oz/ac or greater of 2,4-D or Aquasweep resulted in significant initial injury with values from 90 to 98 percent. In contrast, at one year after treatment (YAT) the control diminished for all treatments, except those containing Roundup Pro Conc. The non-Roundup treatments showed control values ranging from 69 to 75 percent while 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D and 96 oz/ac Aquasweep plus 0.75 oz/ac Escort XP resulted in less control (31 and 54 percent). Treatments containing Roundup Pro Conc. provided 94 and 97 percent control at one YAT. Larger plant size resulted in reduced spray coverage of the canopy, which contributed to lower than expected control levels for 2,4-D. Despite these obstacles, treatments containing glyphosate performed well. Further work using these products, rates, and mixes but applying to the entire canopy and ensuring better coverage should be the focus of future investigations.

INTRODUCTION

The very nature of construction and maintenance of roadways creates disturbed, open areas that provide an ideal setting for the establishment of exotic and invasive species. Low growing shrubs, like exotic shrub honeysuckle, are able to colonize these sites; quickly gaining a foothold and spreading aggressively. Unfortunately, the herbicide tank mixes commonly used by PennDOT in controlling woody plants have had minimal impact on exotic shrub honeysuckle species along Pennsylvania's roads. A trial was established in 2012 to identify chemistry that is both safe to the grass understory and also effective at controlling exotic shrub honeysuckle. This effort identified promising results using 2,4-D or Aquasweep (2,4-D plus triclopyr).[1] For this approach to be useful tank mix partners that would aid in providing broader spectrum control of other woody species encountered in an operational program would be necessary. One potential tank mix partner, the PennDOT Blend, contains MAT28 (aminocyclopyrachlor, ACP) and Escort XP (metsulfuron). An 8 oz rate of the PennDOT Blend equates to 7.67 oz of MAT28 (50% ACP) and 0.33 oz Escort XP. Other possible candidates as tank mix partners with 2,4-D are Garlon 3A or Escort XP while Aquasweep could be combined with Escort XP. Further testing of 2,4-D and Aquasweep in progressive rates and within label guidelines in combination with other herbicides for foliar applied control of Morrow's honeysuckle was the focus of the following experiment.

MATERIALS AND METHODS

The experiment was established in close proximity to the interchange of I-99 and I-80 near Bellefonte, PA. Eight herbicide treatments were tested including: 8 oz/ac PennDOT Blend plus 96 oz/ac 2,4-D; 1 oz/ac Escort XP plus 128 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 128 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 104 oz/ac Roundup Pro Concentrate[2]; 104 oz/ac Roundup Pro Conc. alone; 96 oz/ac Aquasweep plus 0.75 oz/ac Escort XP; 184 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 August 2, 2013, using a CO_2 powered backpack sprayer equipped with a GunJet spray gun and single Boomjet XP 20R nozzle.

Percent injury (0 = no injury, 100 = complete necrosis) to Morrow's honeysuckle was visually rated on September 12, 2013, 41 days after treatment, DAT. Percent control based on percent canopy loss of the treated branches to Morrow's honeysuckle was evaluated on July 31, 2014, 1 year after treatment, YAT. All data were subject 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

Initial injury to Morrow's honeysuckle ranged from 56 to 98 percent for the herbicide treatments at 41 days after treatment, DAT. All treatments containing 96 oz/ac or greater of 2,4-D or Aquasweep resulted in significant injury with values from 90 to 98 percent. Other treatments that included either 64 oz/ac 2,4-D or Roundup Pro Conc. resulted in injury values of 56 to 72 percent. At one YAT, treatments containing Roundup Pro Conc. resulted in the greatest control averaging 94 and 97 percent. Regrowth of the canopy was observed with the remaining treatments resulting in reduced long-term control. Treatments containing 96 oz/ac or greater of 2,4-D or Aquasweep offered moderate control at 69 to 75 percent. While 96 oz/ac Aquasweep plus 0.75 Escort XP only produced 54 percent control. The least effective treatment was 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D producing only 31 percent control.

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[1] Johnson, J.M. et al 2014. Investigating Herbicide Tank Mixes for Control of Morrow's Honeysuckle (Lonicera Morrowii) – Second Year Results. Roadside Vegetation Management Research – 2014 Report. pp 1-4.

[2] 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.

CONCLUSIONS

Using increased rates of 2,4-D and Aquasweep did not provide effective control of the treated branches. However, in this experiment larger shrubs were targeted and only one side of most shrubs received spray to mimic a typical truck-based, sidetrimming spray pattern. Despite the reduced coverage of the Morrow's honeysuckle canopy, treatments containing glyphosate (Roundup Pro Conc.) did defoliate the treated branches and may offer an option where loss of existing understory can be tolerated.

It should be noted that some 2,4-D labels limit the amount of product per acre that can be applied to 64 oz/ac in non-crop areas (e.g., Weedar 64). Proper product selection is crucial to maintain legal compliance.[3] The more liberal 2,4-D products stipulate amounts not to exceed 128 oz/ac in non-crop areas (e.g., DMA 4 IVM)[4], while Aquasweep allows 184 oz/ac as the maximum application rate.[5] An evaluation in 2015 (2 YAT) will confirm whether control levels were maintained or reduced for any of the treatments.

MANAGEMENT IMPLICATIONS

Tank mixes that include 96 to 128 oz/ac 2,4-D plus either 8 oz/ac PennDOT Blend or 64 oz/ac Garlon 3A or, alternatively, 184 oz/ac Aquasweep plus 0.5 oz/ac Escort XP did not offer effective control when sidetrimming exotic honeysuckle shrubs. However, even lesser rates of 2,4-D and Aquasweep in similar tank mixes have shown promising results in past work. With sufficient coverage of the targeted shrubs by the herbicide spray and a planned retreatment to eliminate newly emerging sprouts, effective control would be expected. These tank mixes should also control a spectrum of other common brush species while minimizing impact to the grass understory. The 2,4-D plus Escort XP treatment was added primarily to determine the contribution Escort XP offers on Morrow's honeysuckle control and may prove to be weak on controlling other woody species. Roundup Pro Conc. alone and in combination has offered excellent brush control, including Morrow's honeysuckle, but is damaging to grasses. A targeted application with mixes containing glyphosate or applying on sites that contain little or no desirable understory is an option in some instances. Altering the spray pattern to allow for greater coverage of the shrubs should be investigated to determine if more effective control could be achieved using the elevated rates of 2,4-D and Aquasweep in the tank mix combinations tested in this experiment.

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[3] NuFarm, Inc. Weedar 64 Herbicide. Online. Internet. February 5, 2014.
[4] Dow AgroSciences LLC. DMA 4 IVM. Online. Internet. February 5, 2014.
[5] NuFarm Americas, Inc. Aquasweep Herbicide. Online. Internet. February 5, 2014.

Table 1. Percent injury and control of Morrow's honeysuckle (*Lonicera morrowii*, LONMO). The trial was visually rated for percent injury on September 12, 2013 (41 days after treatment, DAT) and control on July 31, 2014 (1 year after treatment, YAT). Treatments were applied on August 2, 2013. 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 $p \leq 0.05$.

product	rate	Percent Injury (41 DAT) LONMO	Percent Control (1 YAT) LONMO
	(oz/ac)		
untreated	---	0 a	0 a
PennDOT Blend 2,4-D	8 96	94 c	72 cd
Escort XP 2,4-D	1 128	94 c	69 cd
Garlon 3A 2,4-D	64 64	68 bc	31 b
Garlon 3A 2,4-D	64 128	95 c	69 cd
Garlon 3A Roundup Pro Conc.	64 104	56 b	94 ef
Roundup Pro Conc.	104	72 bc	97 f
Aquasweep Escort XP	96 0.75	90 c	54 c
Aquasweep Escort XP	184 0.5	98 c	75 de

EVALUATION OF THE HERBICIDES STREAMLINE® AND VIEWPOINT® FOR CONTROL OF BLACK BIRCH (BETULA LENTA) – SECOND YEAR RESULTS

Herbicide trade and common names: Escort XP (*metsulfuron*); Garlon 3A (*triclopyr* amine); Imazapyr 75WG (*imazapyr*); MAT28 50 SG (*aminocyclopyrachlor*); Streamline (*aminocyclopyrachlor* + *metsulfuron*); Viewpoint (*aminocyclopyrachlor* + *metsulfuron* + *imazapyr*).

Plant common and scientific names: black birch (*Betula lenta,* BETLE), flattened oatgrass (*Danthonia compressa*, DANCO), tapered rosette grass (*Dicanthelium acuminatum*).

ABSTRACT

Unwanted trees and shrubs can quickly invade the roadsides of Pennsylvania where they limit sight distance, form obstacles, and create the potential for falling limbs. Black birch is among the many species that colonize the roadway corridors. New herbicides with varying modes of action are continually investigated to find the most effective chemistry to control woody plants and preserve grasses in the understory.

Aminocyclopyrachlor has shown efficacy in control of a number of tree species on the roadside. DuPont has three herbicide premixes containing the active ingredient *aminocyclopyrachlor* and two (i.e., Streamline and Viewpoint) that are labeled for general weed and brush control along highway rights-of-way. This experiment was established to determine the efficacy of these products at various rates compared to the standard Garlon 3A plus Escort XP combination using foliar applications for control of black birch and safety to grasses.

Review of the site 1-year after treatment, YAT, showed control of black birch and injury symptoms to flattened oatgrass, the predominate grass species present, with all treatments. Streamline at 9.5 oz/ac or greater, Viewpoint at 13 oz/ac or greater, and 64 oz/ac Garlon 3A plus 0.5 oz/ac Escort XP offered excellent control of black birch from 88 to 96 percent. Both Streamline and Viewpoint injured the understory grass; however, Viewpoint, which contains *imazapyr* resulted in the greatest injury.

INTRODUCTION

The goal of managing roadsides in Pennsylvania is to maintain a stable, low growing plant community adjacent to travel lanes, which provides a buffer from standing trees and the hazards associated with them, such as collision targets, falling limbs, and limited sight distance. Trees and shrubs, especially early successional species, quickly gain a foothold in these areas and targeted spraying or removal is used to keep the roadways safe. Herbicide programs are implemented using a variety of tank mixes to target unwanted trees and shrubs. Streamline and Viewpoint are two relatively new products in the marketplace labeled for control of a wide variety of woody species. This experiment examined several rates of each product through foliar applications to control black birch and to determine their effect on understory plants compared to the standard Garlon 3A plus Escort XP herbicide treatment.

MATERIALS AND METHODS

An experiment was established within the right-of-way of SR 322 near Port Matilda, PA. Treatments included Streamline at 7.5, 9.5, and 11.5 oz/ac; Viewpoint at 13, 16.5, and 20 oz/ac; Garlon 3A at 64 oz/ac combined with Escort XP at 0.5 oz/ac; and an untreated check. Methylated seed oil was added to all treatments at 1% v/v. The experiment was established as a randomized complete block design with three replications. Plots were 10 by 30 ft. in size. Black birch had a maximum height of approximately 10 ft and averaged 6 ft tall. Treatments were applied using a CO_2-powered sprayer equipped with an AA30 GunJet spray gun, TeeJet adjustable ConeJet nozzle, and X-6 tip operating at 30 psi for an application volume of 25 gallons per acre. The black birch was treated on July 2, 2013. A brief rain shower with large droplets began while spraying the last plot with enough rain to wet the pavement but ended quickly and was not considered to have impacted the treatments.

Percent injury to black birch was evaluated August 26, 2013, 55 days after treatment, DAT. Percent control of black birch was later evaluated on July 14, 2014, 1 year after treatment, YAT. Both percent injury and control to black birch were a reflection of the percentage of defoliation. Percent injury to the understory in particular ferns and two grass species, flattened oatgrass and tapered rosette grass, were evaluated August 26, 2013 and June 27, 2014 (55 DAT and 1 YAT). However, only flattened oatgrass was present in enough quantity to yield sufficient data for reporting.

RESULTS AND DISCUSSION

Initial injury to black birch was statistically similar and ranged from 43 to 70 percent for all herbicide treatments (Table 1). Streamline herbicide applied at 9.5 oz/ac, Viewpoint at 16.5 or 20 oz/ac, and Garlon 3A at 64 oz/ac plus Escort XP at 0.5 oz/ac resulted in the greatest injury with rating values from 57 to 70 percent. All other treatments including Streamline at 7.5 and 11.5 oz/ac and Viewpoint at 13 oz/ac resulted in injury values of 43 to 47 percent. One year later, excellent control of black birch was observed with Streamline at 9.5 oz/ac or greater, Viewpoint at 13 oz/ac or greater, and Garlon 3A at 64 oz/ac plus Escort XP at 0.5 oz/ac with values from 88 to 96 percent. The lowest rate of Streamline at 7.5 oz/ac resulted in 70 percent control.

At 55 DAT, moderate injury to flattened oatgrass occurred with Viewpoint at 13 and 20 oz/ac, the lowest and highest rates tested in this trial, with 63 and 53 percent injury, respectively (Table 2). All other herbicide treatments resulted in less injury to this grass species from 20 to 37 percent and were not significantly different from the untreated check. By 1 YAT, injury to flattened oatgrass increased for all Streamline and Viewpoint treatments. Both products displayed significant injury symptoms, with Streamline ranging from 48 to 65 percent and Viewpoint from 76 to 100 percent. The Garlon 3A and Escort treatment resulted in the least injury to flattened oatgrass at 18 percent.

CONCLUSIONS

Excellent control of black birch can be expected at rates of Streamline at 9.5 oz/ac or Viewpoint at 13 oz/ac and greater. These products and rates are comparable in their control to the standard tank mix of Garlon and Escort XP used in PennDOT’s weed and brush program

(7713). Nearly permanent loss of the grass understory occurred with Viewpoint while Streamline did allow some grass understory to persist. This would be expected with the addition of *imazapyr* found in Viewpoint. The Garlon 3A and Escort XP treatment showed only a minor impact on the flattened oatgrass.

MANAGEMENT IMPLICATIONS

The 64 oz/ac Garlon 3A and 0.5 oz/ac Escort XP combination is very effective at controlling black birch while causing less damage to the grass understory. Using 9.5 oz/ac Streamline or 13 oz/ac Viewpoint are options to effectively control black birch but greater damage to the understory would be expected, especially using Viewpoint. In addition, caution in using Streamline and Viewpoint should be exercised due to their soil activity and potential to injure nearby desirable trees. For these reasons we do not recommend replacing the standard herbicide combination with these aminocyclopyrachlor products under this roadside scenario.

Table 1. Percent injury and control to black birch (*Betula lenta,* BETLE). The trial was visually rated for percent injury on August 26, 2013, 55 days after treatment, DAT and percent control on July 14, 2014, 1 year after treatment, YAT. Treatments were applied on July 2, 2013. All treatments included 1 percent v/v methylated seed oil. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	rate	Percent Injury BETLE 8/26/13	Percent Control BETLE 7/14/14
	(oz/ac)		
Untreated	---	0 a	0 a
Streamline	7.5	45 ab	70 b
Streamline	9.5	58 b	91 b
Streamline	11.5	43 ab	88 b
Viewpoint	13	47 ab	96 b
Viewpoint	16.5	57 b	95 b
Viewpoint	20	63 b	96 b
Garlon 3A Escort XP	64 0.5	70 b	96 b

Table 2. Percent injury to flattened oatgrass (*Danthonia compressa*, DANCO). The trial was visually rated for percent injury on August 26, 2013, 55 days after treatment, DAT and June 27, 2014, 1 year after treatment, YAT. Treatments were applied on July 2, 2013. All treatments included 1 percent v/v methylated seed oil. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	rate	Percent Injury DANCO 8/26/13	Percent Injury DANCO 6/27/14
	(oz/ac)		
untreated	---	0 a	0 a
Streamline	7.5	20 ab	48 ab
Streamline	9.5	27 ab	65 ab
Streamline	11.5	27 ab	57 ab
Viewpoint	13	63 b	84 ab
Viewpoint	16.5	30 ab	100 b
Viewpoint	20	53 b	76 ab
Garlon 3A Escort XP	64 0.5	37 ab	18 ab

COMPARING FOLIAR APPLIED AMINOCYCLOPYRACHLOR PRODUCTS TO OLDER BRUSH CONTROL MATERIALS IN CONTROLLING RESPROUTING BRUSH AFTER MOWING – SECOND YEAR RESULTS

Herbicide trade and common chemical names: Arsenal or Stalker (*imazapyr*), 2,4-D (2,4-D), Escort XP (*metsulfuron*); Garlon 4 (*triclopyr ester*), Krenite S (*fosamine*); MAT28 50 SG (*aminocyclopyrachlor*), Milestone (*aminopyralid*), Streamline (*aminocyclopyrachlor* + *metsulfuron*); Tordon K (*picloram*), Viewpoint (*aminocyclopyrachlor* + *metsulfuron* + *imazapyr*).

Plant common and scientific names: black locust (*Robinia pseudoacacia*), black walnut (*Juglans nigra*), cherry (*Prunus* spp.), exotic shrub honeysuckle (*Lonicera spp.*), goldenrod (*Solidago spp.*), smooth sumac (*Rhus glabra*).

Abstract

Mowing is an effective way to remove dense stands of brush and small caliper trees from the right-of-way. Without herbicide treatment, many stems will resprout and rapidly revegetate the area. Where stem density is high, allowing the cut stems to resprout and treating the emerging stems and leaves with a foliar application is an alternative to cut stump treatment. This experiment was designed to evaluate the performance of foliar applications of Viewpoint and Streamline, both products containing *aminocyclopyrachlor*, alone and in combination with other brush control herbicides on resprouting woody vegetation following mowing. Percent mortality data collected 1 year after treatment, YAT, showed that tank mixes of older chemistries (i.e., 2,4-D, Garlon 4, Escort XP) controlled exotic shrub honeysuckle equally as well as treatments containing *aminocyclopyrachlor* (52 to 73 percent). Tordon K and Garlon 4 resulted in the highest mortality (87%) to exotic shrub honeysuckle, while Tordon K combined with Stalker and Milestone resulted in the lowest mortality rating at 27 percent.

Introduction

Mowing is cost effective at removing woody vegetation along the right-of-way when stems are too dense for basal stem treatments yet small enough for cutting with a brush mower. Many of the cut stems will resprout if not treated with an herbicide. When stem densities are high, cut stump treatments are labor intensive and require a relatively high concentration of herbicide to be effective. Another way to treat cut stems is to allow them to resprout and apply an herbicide to the developing leaves and stems. This experiment was designed to compare the performance of two aminocyclopyrachlor products (i.e.,Viewpoint and Streamline) to other brush control herbicides as a foliar application for controlling resprouting woody vegetation following mowing.

Materials and Methods

The experiment was established within the right-of-way of I-80 westbound near Lamar, PA. Treatments included Streamline at 9.5 and 11.5 oz/ac with or without Krenite S at 128 oz/ac; Viewpoint at 13 and 16.5 oz/ac; Viewpoint at 9.5 oz/ac and Streamline at 6 oz/ac; Tordon K at 64 oz/ac combined with Stalker at 16 oz/ac and Milestone at 7 oz/ac; Tordon K at 64 oz/ac and

Garlon 4 at 128 oz/ac; Garlon 4 at 64 oz/ac combined with 2,4-D at 64 oz/ac and Escort XP at 0.5 oz/ac; and an untreated check. Methylated seed oil was added to all treatments at 1% v/v. The experiment was established as a randomized complete block design with four replications. Plots were 20 by 30 ft. in size. Target species included mainly exotic shrub honeysuckle; however, other species such as cherry, walnut, black locust, and smooth sumac were scattered in lesser numbers throughout the trial area. Treatments were applied using a CO_2-powered sprayer equipped with a six foot boom and four (4) 8004 VS nozzles operating at 30 psi applying 50 gallons per acre. The trial area was cut/mowed by PennDOT crews during the winter of 2012/2013 and herbicide treatments were applied on May 30, 2013.

Percent defoliation to exotic shrub honeysuckle (*Lonicera spp*., LONXX) and other woody species present within each plot was evaluated September 19, 2013, 112 days after treatment, DAT. Percent injury to the goldenrod (*Solidago spp*., SOLXX) understory was also evaluated September 19, 2013, 112 DAT. Percent mortality to exotic shrub honeysuckle and other woody species present within each plot (i.e, percentage of stumps devoid of living sprouts) was evaluated on June 3, 2014, 1 year after treatment, YAT.

Results and Discussion

At 112 DAT, defoliation of bush honeysuckle ranged from 73 percent for the Tordon K, Stalker, Milestone mix to 95 percent for Tordon K plus Garlon 4, with no statistically significant differences between herbicide treatments. Only three treatments failed to provide at least 80 percent defoliation, Streamline at 9.5 oz/ac; Streamline at 9.5 oz/ac plus Krenite at 128 oz/ac; and Tordon K at 64 oz/ac combined with Stalker at 16 oz/ac, and Milestone at 7 oz/ac. Injury to goldenrod understory was high (97.5 to 100 percent) and almost uniform across herbicide treatments. By 1 YAT, Tordon K plus Garlon 4 continued to offer the highest level of control at 87 percent mortality. All treatments containing Streamline or Viewpoint and the Garlon 4 combined with 2,4-D and Escort XP, provided statistically similar mortality of exotic shrub honeysuckle from 52 to 73 percent. The Tordon K, Stalker, and Milestone treatment produced the least mortality to exotic shrub honeysuckle (27 percent).

Conclusions

Results generated 1 YAT show that the tank mix using the older chemistries (i.e., 2,4-D, Garlon 4, Escort XP) controlled exotic shrub honeysuckle as well as mixes that contained *aminocyclopyrachlor*. These treatments offered only moderate levels of control; however, at the rates and combinations evaluated in this experiment. Though similar to these treatments, Tordon K plus Garlon 4 demonstrated the highest mortality and remains a viable option for this application method. The herbicide mix containing Tordon K, Stalker, and Milestone provided the lowest mortality.

Management Implications

Tordon K is not used by PennDOT because of the restricted use label. However, it remains a viable option for this type of application method when combined with Garlon 4. All other herbicide treatments tested resulted in less than acceptable mortality of exotic shrub honeysuckle sprouts after one year. Adjustments in rates or tank mix partners are required in future testing to identify treatments that will work on exotic shrub honeysuckle using foliar applications targeting aggressively sprouting stumps.

Table 1. Defoliation and mortality to exotic shrub honeysuckle (*Lonicera* spp., LONXX) and injury to goldenrod (*Solidago* spp., SOLXX) understory along I-80 East near Lamar, PA. Trees and brush were mowed during the winter of 2012/2013. Herbicide treatments were applied to regrowth on the cut stubble on May 30, 2013 at 50 gallons per acre. Visual ratings of percent defoliation LONXX and injury SOLXX were performed on September 19, 2013 (112 days after treatment, DAT). Percent mortality to LONXX was evaluated on June 3, 2014 (1 year after treatment, YAT). Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

treatment	rate	percent defoliation LONXX Sept 19, 2013	percent mortality LONXX June 3, 2014	percent injury SOLXX Sept 19, 2013
	(oz/ac)			
Untreated	---	0 a	0 a	0 a
Streamline	9.5	79 b	52 bc	100 c
Streamline	11.5	83 b	59 bc	100 c
Streamline Krenite S	9.5 128	79 b	73 bc	100 c
Streamline Krenite S	11.5 128	86 b	68 bc	100 c
Viewpoint	13	88 b	58 bc	99.8 bc
Viewpoint	16.5	85 b	60 bc	100 c
Viewpoint Streamline	9.5 6	84 b	64 bc	100 c
Tordon K Stalker Milestone	64 16 7	73 b	27 ab	99.8 bc
Tordon K Garlon 4	64 128	95 b	87 c	100 c
Garlon 4 2,4-D Escort XP	64 64 0.5	88 b	59 bc	97.5 b

COMPARISON OF HERBICIDE AND MOWING REGIMES FOR CONTROL OF CANADA THISTLE IN A GRASS GROUNDCOVER

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 plant found throughout Pennsylvania that is listed as both a state and federal noxious weed. 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 development by the root system. In an effort to address Canada thistle colony expansion while effectively managing costs, a long-term experiment comparing alternative management strategies was initiated. Part one of this experiment was a two-season program initiated in 2010. The program included a spring treatment of mowing or herbicide treatment (chemical mowing) to eliminate seed set and reduce the carbohydrate reserves within the root system of the Canada thistle. This was followed by a fall mowing or application of one of the following herbicides or herbicide combinations: Milestone VM, a combination of Milestone VM and Overdrive, or a combination of Perspective and Overdrive. 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 experiment. 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. The number of Canada thistle stems was significantly lower at the Indiana fall herbicide treated plots compared to fall mowed. This reduction in Canada thistle stems 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.

Part two of this study started in May of 2013. The existing plots were divided in half to provide a comparison of mowed versus non-mowed treatments to determine the ability of Canada thistle to re-establish and expand. Herbicide treatments from part one of the study were discontinued with the fall 2012 application. During part two, Canada thistle stem counts increased while turf cover decreased in both the mowed and unmowed plots. The regrowth of Canada thistle in both mowed and non-mowed plots at both sites suggests that regular herbicide treatments will be necessary to prevent Canada thistle regrowth and establishment.

INTRODUCTION

Canada thistle is a noxious perennial weed common to both Pennsylvania farmland and roadsides. 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, part one of an experiment 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 followed by a fall control treatment of either mowing or an application of herbicide. The herbicides used in the fall control were Milestone VM alone or combinations of Milestone VM and Overdrive, or Perspective and Overdrive. This experiment 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. Part two of this experiment, overlayed on the existing plots at both sites, was designed to look at the level of Canada thistle re-infestation under a mowed vs. non-mowed regime for two growing seasons after herbicide treatments were discontinued. A previous report details first year findings of part one of this experiment.[3] This report contains final results from part one of the experiment at two years after inception and also presents data from part two of the experiment following two additional growing seasons.

MATERIALS AND METHODS

The experiment was replicated at two sites, one on the shoulder of SR 30W near the Mountville exit and the second next to the SR 422E entrance ramp near Indiana, PA. The six treatments used in the first part of the experiment 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 and Overdrive (*dicamba + diflufenzopyr*) at 4 oz/ac fall, 4) mow spring and apply Perspective (*aminocyclopyrachlor + chlorsulfuron*) at 2 oz/ac and 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 and 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 and Overdrive at 4 oz/ac fall. All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v.

Plot size was 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

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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.

8004-VS spray nozzles. Both experiments 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 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 DAIT and May 24 and September 20, 2012, at 608 and 727 DAIT. Starting in September 2011 visual ratings for total vegetative cover, cover by turf, and cover by Canada thistle within each plot was also recorded at both locations.

In May of 2013 part two of the experiment was laid out over the existing plots at both the Mountville and Indiana sites. New treatments were imposed with half of each existing plot being mowed two times per year and the other half would be left unmowed. Three new 2 square foot subplots for sampling Canada thistle populations were established in each half of the newly created paired plots. Thistle stems were counted in the late spring and fall of 2013 and 2014. Mowing was accomplished with a Kubota LT2500 tractor with a five-foot wide 3-point hitch flail mower. Quantitative data were subjected to analysis of variance. Data collected from both part one and part two of the study were statistically analyzed and when treatment effect F tests were significant ($p \leq 0.05$), means were compared using the Tukey's HSD test.

RESULTS AND DISCUSSION

Part One

In the spring of 2010, 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 experiment and there were no significant differences among the anticipated treatment plots. 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).

In the Spring of 2010, 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 treatment plots (Table 3). 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. Stem counts among the chemical treatments were not significantly different. Mowing two times per season did not reduce Canada thistle stems to the same degree that either mowing plus herbicide treatments or two herbicide treatments per year did 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. 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 (Table 4). 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, respectively.

Part Two

Since part two was laid out over part one of the experiment, the initial thistle counts across the plots were the same as reported for October 2012. At the Mountville site, very few thistle stems were present in any of the plots and no thistle stems were reported in any of the subplots (Table 1). After imposing mow versus unmowed treatments for two seasons it was found that mowing did not offer a significant advantage at reducing thistle stem numbers or increasing turf cover (Table 5). There was a 6 to 7 fold increase in thistle stems from the May 2012 stem count in both the mowed and non-mowed plots by fall of 2014. Percent turf cover slightly decreased in both the non-mowed and the mowed plots over the same period. Data from the Indiana site portrays a similar picture (Table 6), although thistle stem counts were higher at the start at this location. During part two of the experiment the thistle stem counts at Indiana increased (between 2 and 2.5 times) and percent turf cover decreased.

CONCLUSIONS

In the fall of 2012, two years after initiating part one of the experiment, all treatments reduced the number of Canada thistle stems present. 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 were 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 experiment 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.

Mowing did not substantially contribute to control of Canada thistle populations in part two of this experiment and thistle slowly began to reinfest the sites over a two-year period. However mowing is still a desirable maintenance operation because when properly timed, it helps to control seed set in Canada thistle and other broadleaf weeds plus encourages the development of dense turf. At some point, chemical treatments will likely have to be applied to control Canada thistle that will continue to reemerge as a prominent pest.

MANAGEMENT IMPLICATIONS

Management strategies that employ a spring mowing or herbicide treatment followed by a fall applied herbicide component appears 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.

The herbicide, rates, and combinations tested in this experiment have proven effective and offer excellent options for selectively controlling Canada thistle in turf. Caution should be used with some products, like Perspective, that can be injurious if used within the root zone of some desirable tree species. Always consult and make sure to remain in compliance with the label when selecting herbicides for a particular application and location.

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 $p \leq 0.05$.

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 $p \leq 0.05$.

	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

Table 5. Thistle stem counts and percent turf cover for the SR 30 trial site near Mountville, PA. Part two of the trial was started on May 22, 2013, when the existing plots were divided in half to provide an area for a cut and an uncut treatment. Herbicide treatments from the initial trial were discontinued. Numbers represent the mean of three replications. At this site, differences in thistle stem count and percent turf cover between cut and uncut plots were not significantly different.

	Thistle stems per square foot		% Turf cover	
Mowing Status	Stem Count May 2013	Stem Count October 2014	% Turf Cover May 2013	% Turf Cover October 2014
Cut	.075	0.47	68.22	63.56
Uncut	.075	0.55	64.72	60.5
	n.s.	n.s.	n.s.	n.s.

Table 6. Thistle stem counts and percent turf cover for the SR 422 trial site near Indiana, PA. Part two of the trial was started on May 20, 2013, when the existing plots were divided in half to provide an area for a cut and an uncut treatment. Herbicide treatments from the initial trial were discontinued. Numbers represent the mean of three replications. At this site, differences in thistle stem count and percent turf cover between cut and uncut plots were not significantly different.

	Thistle stems per square foot		% Turf cover	
Mowing Status	Stem Count May 2013	Stem Count October 2014	% Turf Cover May 2013	% Turf Cover October 2014
Cut	0.65	1.6	86.1	69.7
Uncut	0.8	1.7	86.4	68.6
	n.s.	n.s.	n.s.	n.s.

CONVERSION OF CANADA THISTLE INFESTED CROWNVETCH GROUNDCOVER TO FINE FESCUE TURF – SECOND YEAR RESULTS

<u>Herbicide trade and common names</u>: Garlon 3A (*triclopyr*), Milestone VM (*aminopyralid*), PDT Custom Blend (*aminocyclopyrachlor + metsulfuron*), Roundup Pro Concentrate (*glyphosate*), Transline (*clopyralid*), Triplet LO (*2,4-D + mecoprop-p + dicamba*)
<u>Plant common and scientific names</u>: Annual ryegrass (*Lolium multiflorum*), Canada thistle (*Cirsium arvense*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), hard fescue (*Festuca longifolia*), Kentucky bluegrass (*Poa pratensis*), tall fescue (*Festuca arundinacea*).

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. Herbicides that will spare the crownvetch yet provide some control of broadleaf weeds is limited. Converting an area from crownvetch to fine fescue turf while eliminating the Canada thistle allows for better future broadleaf weed 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. 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 several herbicide treatments to control crownvetch and Canada thistle while identifying the best timing for turfgrass seeding after treatment. For this experiment a fall herbicide: fall seeding scenario was compared to a fall herbicide:spring seeding scenario. This experiment also allowed us to determine the effect of a residual herbicide on fine fescue establishment success. The herbicide treatments included: 1) Milestone VM at 7 oz/ac, 2) Roundup Pro Concentrate at 104 oz/ac and Transline at 8 oz/ac, 3) PDT Custom Blend at 8 oz/ac, 4) PDT Custom Blend at 4 oz/ac and Garlon 3A at 64 oz/ac, 5) a cut and seed treatment with no herbicide applied, and 6) a no herbicide and no seeding control. The plots were prepared by loosening the soil with a disc harrow immediately prior to seeding to assure good seed-soil contact. Plots were 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. at two sites, Old Fort and Thompsontown, respectively.

Two years after initiation of the experiment there was tremendous variability between the sites. Significant reductions in Canada thistle (between 80 and 99 percent) were observed at both locations where treatments were imposed. The two exceptions were fall applied Roundup Pro and Transline or no herbicide treatment followed by a spring seeding at the Thompsontown site (56 and 57 percent). The Thompsontown site showed poor overall turf establishment in the spring-seeded (6.3 to 16.5 percent) versus fall seeded plots (61.3 to 72.5 percent). By September 2014, the Old Fort site had 38.8 to 80.5 percent turf cover, except for the fall applied 8 oz/ac Custom Blend followed by a fall seeding or spring seeding alone (21.3 and 30.5 percent). The product rate and short interval of three weeks from herbicide treatment to seeding may have inhibited seed germination using 8 oz/ac Custom Blend. Employing herbicide treatments

followed by seeding to fine fescue in either fall or spring appears effective; however, site conditions may play a role in conversion success as observed with the failed spring seeding at Thompsontown. This research represents preliminary work to develop a conversion and reseeding strategy for use along roadside corridors.

INTRODUCTION

Crownvetch has historically been the low maintenance ground cover of choice for steep slopes along roadsides where rocky, mineral soils predominate. Conversely, 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 crownvetch are limited. Converting crownvetch into turf is an attractive option to simplify ongoing maintenance procedures because more options for broadleaf weed control are available in turf including more frequent mowing cycles and a wider range of herbicides choices. 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 to determine the best time to seed turf following a fall application of these herbicide treatments.

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 and the second in the median of SR 322 near the Thompsontown exit. Both sites were organized into 24 by 30 foot plots in a randomized complete block design with 4 replications.

All plots were mowed with a tractor mounted flail mower to a height of 5 inches to replicate the standard maintenance practice used to remove Canada thistle seed heads and reduce seed dispersal on June 21 and 28, 2012, Old Fort and Thompsontown respectively Herbicide treatments were applied on September 5 and September 7, respectively. The plots were prepared immediately before seeding using a disc harrow mounted on a Kubota L2500 tractor. Fall and spring seeded plots were broadcast with PennDOT Formula L seed mix (Table 1) at 24 lbs. per 1000 sq. yds. September 26, 2012 or April 11, 2013 and October 5, 2012 or April 16, 2013 for the Old Fort and Thompsontown sites, respectively. The amount of fertilizer applied was based on soil test result recommendations from the Penn State Agricultural Analytical Services Laboratory and was 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 (Old Fort and Thompsontown, respectively).

The herbicide treatments included: 1) Milestone VM at 7 oz/ac, 2) Roundup Pro Concentrate at 104 oz/ac and Transline at 8 oz/ac, 3) PDT Custom Blend at 8 oz/ac, 4) PDT Custom Blend at 4 oz/ac and Garlon 3A at 64 oz/ac, and 5) a cut only treatment, followed by seeding with no herbicide application. The treatments also included a control plot where no herbicide or seed was applied. All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v and

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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.

were applied with a CO_2 powered backpack sprayer at 35 psi with a 6 ft. boom equipped with four 8004VS nozzles. Canada thistle stem counts were recorded prior to treatment (August 2012) and four times following treatment (June and October 2013 plus June and September 2014) by counting and tallying the number of stems in three 11 sq. ft. subplots at fixed locations within each plot. A percent coverage visual rating for Canada thistle, desirable turf (defined as fine fescue and annual rye in the Formula L seed mix), and total plot cover were collected for each plot on the same dates as the stem counts. In June 2013, all plots except the non-seeded treatment were sprayed with Triplet LO at 64 oz/ac + CWC 90 surfactant at 0.25% v/v to protect the developing turf stands from being overtopped with broadleaf weeds. Beginning in October 2013, all plots were mowed with a tractor mounted flail mower after each rating.

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

RESULTS AND DISCUSSION

For the June 2013 rating, Canada thistle stem counts for all herbicide treatments for both fall and spring seeded plots decreased dramatically from pretreatment values established in August 2012 (Tables 2 and 3). PennDOT Custom Blend at 8 oz. followed by a fall or spring seeding performed best across both sites and produced a 99 to 100 percent reduction in thistle stems, but this treatment did not separate out as statistically different from the other herbicide treatments. The initial number of Canada thistle stems averaged 43 to 48 and declined to an average of 0 to 0.3 by June 2013 for this herbicide treatment at either seeding date. Even the poorest performing herbicide and seeding timing combination (Roundup Pro at 104 oz. + Transline at 8 oz. followed by spring seeding) reduced thistle stem counts from 60 to 14.8 (75% reduction) and from 47 to 13.8 (71% reduction) at Thompsontown and Old Fort, respectively. The Roundup Pro + Transline combination performed better when followed by fall seeding, reducing mean thistle stem counts at Thompsontown from 33 to 2 (94% reduction) and at Old Fort from 41 to 7.8 (81% reduction). The seeding alone treatment reduced thistle stem counts at both sites, with Formula L plots established in the fall demonstrating a reduction of thistle plants greater than twice that observed for spring seeded turf. A look at the June thistle counts for the seed only plots showed that on fall seeded plots thistle stem counts decreased 55% (from 40 to 18) and 40% (from 46 to 27.5) while spring seeded turf produced a reduction of only 12% (32 to 28.1) and 20% (49 to 39.2) at Thompsontown and Old Fort, respectively.

Two years after initiation of the experiment (i.e., Sept 2014) there was tremendous variability between the sites. At the Thompsontown site, the fall seeded plots averaged 68 percent fine fescue turf cover, whereas spring-seeded plots averaged 12 percent cover, whether herbicides were applied or not (Table 4). We speculate that external factors reduced turf establishment in the spring-seeded plots (i.e., high vole population and competing perennial grasses). All treatment plots (fall and spring) resulted in an 80 to 97 percent reduction in Canada thistle except for two spring-seeded treatments which received 104 oz/ac Roundup Pro and 8 oz/ac Transline and a cut only treatment each of which reduced thistle by 56 and 57 percent, respectively. The Old Fort location produced 38.8 to 80.5 percent turf cover across seeding times with two exceptions (Table 5). First, a fall-seeded treatment where 8 oz/ac Custom Blend was applied and 21.3 percent turf cover resulted. We speculate that the herbicide treatment may have inhibited turf establishment due to a three-week treatment prior to seeding. The second exception was found where, a spring-seeding occurred with no herbicide treatment and a 30.5 percent turf cover was recorded. At the Old Fort site, all seeded treatments resulted in an 88 to 99 percent reduction in Canada thistle.

CONCLUSIONS

All of the herbicides selected for fall application in this experiment were known to be somewhat persistent in the soil and active against Canada thistle. All treatments including the seed only plots produced dramatic reduction of Canada thistle stems. It appears that the three pronged approach of mowing or applying an herbicide at bloom time followed by a fall application of a persistent herbicide, in combination with the establishment of a turf groundcover was effective; however, site conditions may play a role in conversion success.[2] PennDOT Custom Blend at 8 oz./ac. was most effective at reducing the number of thistle stems present for the June 2013 rating, but this treatment did not separate out statistically from the other herbicide treatments. It also may have been inhibitory to germinating seed with the short interval of three weeks between herbicide treatment and seeding.

For the seed only plots, it is interesting to note the relationship between thistle stem reduction and cover by desirable turf. The seed only, fall seeded treatment (Sept 2014 rating), reduced thistle stem counts by 93 and 89 percent with a desirable turf cover of 68.8 and 66 percent at the Thompsontown and Old Fort sites, respectively. For the seed only, spring seeded plots (Sept 2014 rating), thistle stem counts dropped by only 57 percent where cover by desirable turf was a low 9 percent at the Thompsontown site. In contrast, thistle stem counts were dramatically reduced by 95 percent even with 30.5 percent desirable turf cover at the Old Fort site. This reinforces the idea that Formula L turf competition is contributing to Canada thistle control in this experiment.

The collapse of the newly developing turf in the spring-seeded treatments during the summer of 2013 at the Thompsontown site is somewhat of a mystery. One possible explanation is that rodents consumed the turf. A large number of rodents were present when the tractor disturbed the site during mowing. It is possible that the rodents were attracted to the spring seeded plots by the mature seeds produced by the annual ryegrass component of the Formula L seed mix. While in these plots eating the seed, rodents could also have consumed or damaged the fine fescue plants that had germinated. Fall seeded plots had no annual rye seedheads because frost killed the plants before seed could be produced.

MANAGEMENT IMPLICATIONS

Current recommendations for managing Canada thistle consist of an herbicide or mowing treatment to prevent seed set and reduce energy reserves in the root system followed by fall

[2] Gover et al. 2007. Managing Canada Thistle, Factsheet 1, Conservation Reserve Enhancement Program Technical Assistance Series. http://plantscience.psu.edu/research/projects/vegetative-management/publications.

application of an herbicide that has some persistent activity. Data from this experiment suggests that establishing a competitive turf groundcover aids in suppression of thistle stems and enhances the effect of other control methods. Continued monitoring and maintenance of sites that were once infested with Canada thistle will be necessary to prevent Canada thistle populations from recovering.

PennDOT Custom Blend at 8 oz./ac. may have caused some inhibition of turf seed (Formula L) germination when seeded at three weeks after herbicide application. Site conditions may dictate the use of other turfgrass species that could vary in tolerance to herbicide residuals in the soil.

Table 2. Canada Thistle Stem Counts per square meter at the Thompsontown site. Each stem count is the mean of 3 subplots in each of 4 repetitions. The initial number of Canada thistle stems was counted on August 28, 2012. Herbicide treatments were applied on September 7, 2012 and plots seeded October 5, 2012 (fall seed) or April 16, 2013 (spring seed). Thistle stems were counted on June 18, 2013 (284 days after treatment, DAT) and September 23, 2014 (742 DAT). The percent reduction in thistle stems from pre-treatment numbers was calculated for each thistle stem count. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Initial Stem Count 8/28/2012	Stem Count June 2013 284 DAT	Percent Canada Thistle Reduction June 2013 284 DAT	Stem Count Sept 2014 742 DAT	Percent Canada Thistle Reduction Sept 2014 742 DAT
Fall 2012 Seed	40	18.0 bc	55	2.7 a	93
Milestone VM 7, Fall Seed	40	2.0 ab	95	4.3 a	89
Roundup Pro 104, Transline 8, Fall Seed	33	2.0 ab	94	2.0 a	94
Custom Blend 8, Fall Seed	43	0.0 a	100	1.1 a	97
Custom Blend 4, Garlon 64, Fall Seed	36	0.1 a	100	6.6 a	82
Spring 2013 Seed	32	28.1 c	12	13.9 abc	57
Milestone VM 7, Spring Seed	45	0.7 a	98	5.9 a	87
Roundup Pro 104, Transline 8, Spring Seed	60	14.8 abc	75	26.1 c	56
Custom Blend 8, Spring Seed	45	0.2 a	100	3.7 a	92
Custom Blend 4, Garlon 64, Spring Seed	41	0.8 a	98	8.1 ab	80
No 2012 herbicide app., No 2012 or 2013 seeding	41	22.9 c	44	24.6 bc	40
	N.S.				

Table 3. Canada Thistle Stem Counts per square meter at the Old Fort site. Each stem count is the mean of 3 subplots in each of 4 repetitions. The initial number of Canada thistle stems was counted on August 27, 2012. Herbicide treatments were applied on September 5, 2012 and plots seeded September 26, 2012 (fall seed) or April 11, 2013 (spring seed). Thistle stems were counted on June 12, 2013 (280 days after treatment, DAT) and September 17, 2014 (742 DAT). The percent reduction in thistle stems from pre-treatment numbers was calculated for each thistle stem count. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Initial Stem Count 8/27/2012	Stem Count June 2013 280 DAT	Percent Canada Thistle Reduction June 2013 280 DAT	Stem Count Sept 2014 742 DAT	Percent Canada Thistle Reduction Sept 2014 742 DAT
Fall 2012 Seed	46	27.5 c	40	5.2 ab	89
Milestone VM 7, Fall Seed	58	7.4 ab	87	5.1 ab	91
Roundup Pro 104, Transline 8, Fall Seed	41	7.8 ab	81	4.9 ab	88
Custom Blend 8, Fall Seed	48	0.3 a	99	2.7 ab	94
Custom Blend 4, Garlon 64, Fall Seed	43	0.3 a	99	1.4 ab	97
Spring 2013 Seed	49	39.2 c	20	2.6 ab	95
Milestone VM 7, Spring Seed	49	6.1 ab	88	0.3 a	99
Roundup Pro 104, Transline 8, Spring Seed	47	13.8 b	71	1.9 ab	96
Custom Blend 8, Spring Seed	47	0.0 a	100	1.0 ab	98
Custom Blend 4, Garlon 64, Spring Seed	44	3.4 ab	92	1.9 ab	96
No 2012 herbicide app., No 2012 or 2013 seeding	49	27.6 c	44	7.8 b	84
	N.S.				

Table 4. Visual rating of percent cover by desirable turf at the Thompsontown site. Herbicide treatments were applied on September 7, 2012 followed by seeding October 5, 2012 (fall seed) or April 16, 2013 (spring seed). The plots were visually rated for cover on June 18, 2013 (284 days after treatment, DAT) and September 23, 2014 (742 DAT). Ratings represent the mean of 4 repetitions. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Percent Cover June 2013 284 DAT	Percent Cover Sept 2014 742 DAT
Fall 2012 Seed	35.0 ab	68.8 b
Milestone VM 7, Fall Seed	50.0 ab	61.3 b
Roundup Pro 104, Transline 8, Fall Seed	70.0 b	72.5 b
Custom Blend 8, Fall Seed	53.8 ab	67.3 b
Custom Blend 4, Garlon 64, Fall Seed	57.3 b	68.3 b
Spring 2013 Seed	25.3 ab	9.0 a
Milestone VM 7, Spring Seed	28.8 ab	15.8 a
Roundup Pro 104, Transline 8, Spring Seed	64.0 b	11.5 a
Custom Blend 8, Spring Seed	57.5 b	6.3 a
Custom Blend 4, Garlon 64, Spring Seed	36.0 ab	16.5 a
No 2012 herbicide app., No 2012 or 2013 seeding	0.0 a	0.0 a

Table 5. Visual rating of percent cover by desirable turf at the Old Fort site. Herbicide treatments were applied on September 5, 2012 followed by seeding September 26, 2012 (fall seed) or April 11, 2013 (spring seed). The plots were visually rated for cover on June 12, 2013 (280 days after treatment, DAT) and September 17, 2014 (742 DAT). Ratings represent the mean of 4 repetitions. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Percent Cover June 2013 280 DAT	Percent Cover Sept 2014 742 DAT
Fall 2012 Seed	26.3 abc	66.0 bc
Milestone VM 7, Fall Seed	46.3 bc	53.0 bc
Roundup Pro 104, Transline 8, Fall Seed	40.0 abc	65.0 bc
Custom Blend 8, Fall Seed	9.5 ab	21.3 ab
Custom Blend 4, Garlon 64, Fall Seed	35.0 abc	46.3 bc
Spring 2013 Seed	16.3 abc	30.5 ab
Milestone VM 7, Spring Seed	55.8 c	38.8 abc
Roundup Pro 104, Transline 8, Spring Seed	53.8 c	79.5 c
Custom Blend 8, Spring Seed	48.8 bc	65.5 bc
Custom Blend 4, Garlon 64, Spring Seed	56.0 c	80.5 c
No 2012 herbicide app., No 2012 or 2013 seeding	0.0 a	0.0 a

COMPARISON OF PLATEAU AND PANORAMIC TANK MIXES FOR TURF GROWTH REGULATION AND BROADLEAF WEED CONTROL

Herbicide trade and common names: Embark (*mefluidide*), Escort XP (*metsulfuron*), Method (*aminocyclopyrachlor*), Milestone (*aminopyralid*), Panoramic (*imazapic*), PennDOT (PDT) Custom Blend (*aminocyclopyrachlor* + *metsulfuron*), Perspective (*aminocyclopyrachlor* + *chlorsulfuron*), Plateau (*imazapic*).

Plant common and scientific names: chicory (*cichorium intybus*, CHIIN), crownvetch (*Coronilla varia*, CZRVA), Kentucky blue grass (*Poa pratensis*, POAPR), quackgrass (*Elytrigia repens*, AGRRE), smooth brome (*Bromus inermis*), tall fescue (*Festuca arundinacea*, FESAR).

ABSTRACT

Turf growth regulators are used to suppress the development of grasses in order to reduce the number of mechanical mowing cycles needed on the roadside. There is an active PennDOT program specific to this application (7711-03) that has used a combination of Embark plus Escort XP and a broadleaf weed herbicide component as a standard mix for many years. This experiment investigates alternative chemistry for the turf growth regulator program. Plateau and Panoramic both contain the active ingredient imazapic and are labeled for the suppression of roadside cool-season turf. Generally, these products are suggested at rates of 2 to 4 oz/ac for this type of treatment on turf species common to Pennsylvania roadsides; however, several precautions are noted on the label. Additionally, a broadleaf herbicide is added to ensure the treated area does not develop a tall canopy of unwanted weeds. The experiment discovered that both Plateau and Panoramic used at 2 oz/ac combined with Perspective or PennDOT Custom Blend offered growth suppression of the grasses and broadleaf weed control similar to the standard, Embark, Escort XP, plus Milestone treatment.

INTRODUCTION

Turf growth regulators, TGRs, combined with broadleaf herbicides are sometimes used by the Pennsylvania Department of Transportation, PennDOT, to suppress the development of turfgrass and decrease weed populations. This treatment is meant to reduce the number of mowing cycles conducted in the spring when the cool-season grasses are undergoing rapid growth. TGR applications are often made where mechanical mowing operations are difficult due to traffic hazards or obstacles. These applications are generally a cost saving measure that eliminates added mowing cycles and offer an alternative to complete reliance on mechanical operations.

The standard TGR mix contains Embark, Escort XP, plus a broadleaf weed control component. Plateau and the generic equivalent Panoramic are labeled and recommended for the growth regulation of cool-season roadside grasses.[1,2] Rates of 2 to 4 oz/ac of product are suggested for K-31 tall fescue and "wildtype" Kentucky bluegrass species commonly found on Pennsylvania right-of-ways. Even at these rates; however, precautions are stated on the label

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[1] Plateau, BASF Corporation, Research Triangle Park, NC.
[2] Panoramic, Alligare, LLC, Opelika, AL.

eliminating the use of surfactants at rates of 4 oz/ac, avoiding methylated seed oils, and offering a very short list of turf species tolerant to the products. This experiment investigates these alternative chemistries in combination with a broadleaf herbicide (i.e., Perspective or PennDOT Custom Blend) for this application.

MATERIALS AND METHODS

The experimental site was located on the shoulder of SR 45 near the Old Fort exit of SR322, about 5 miles east of State College, PA. Plots were six by twenty feet in size and were arranged a randomized complete block design with four replications. Treatments included Plateau or Panoramic at 2 oz/ac combined with Perspective at 3 oz/ac; Plateau or Panoramic at 2 oz/ac combined with PennDOT Custom Blend at 4 oz/ac; Embark at 6 oz/ac combined with Escort XP at 0.20 oz/ac and Milestone VM at 5 oz/ac; and an untreated check. The 4 oz rate of PennDOT Custom Blend is equivalent to 3.84 oz Method plus 0.16 oz Escort XP. Induce, a non-ionic surfactant (NIS) at 0.25% v/v, was added to all treatments. Treatments were applied on May 13, 2014 at 35 gal/ac using a CO_2-powered backpack sprayer equipped with a six-foot boom and four 8002VS nozzles.

The trial was visually rated for percent total turf cover, cover by tall fescue (FESAR) and Kentucky bluegrass (POAPR) and percent cover by crownvetch (CZRVA) on May 13, June 13, July 11, September 12, and October 14, 2014 (i.e. 0, 31, 59, 122, and 154 days after treatment, DAT), respectively. Percent cover by chicory (CHIIN) was evaluated from the July to October ratings. The plots were rated for turf phytotoxicity at all rating intervals except the date of application; however, only those recorded at 31 and 59 DAT are reported. Turf phytotoxicity was rated on a scale of 0 to 10 where “0” = no visible yellowing or necrosis; “5” = moderate chlorosis, some necrosis; and “10” = dead. Seedhead suppression was evaluated during the June and July evaluations only. Percent seedhead suppression reflects the reduction of tall fescue and Kentucky bluegrass seedheads compared to the untreated check with consideration for the amount of each species present within the plot. 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

Plateau and Panoramic combined with either Perspective or the PennDOT Custom Blend performed equally well to one another and the standard Embark, Escort XP, and Milestone treatment. All treatments showed signs of phytotoxicity to the turfgrass at 31 DAT, but this symptom was transient and negligible or no longer apparent by 59 DAT (Table 1). Seedhead suppression was also similar for all treatments and ranged from 94 to 97 percent at 59 DAT.

One concern with the use of TGRs is the potential for thinning of the turfgrass stand. An overall evaluation of the turf cover suggested that none of the treatments were detrimental to the turf density. At the onset of the experiment turf cover was similar and ranged from 54 to 70 percent for all treatments, including the untreated check (Table 2). By the final evaluation, 154 DAT, turf cover was similar ranging from 84 to 97 percent for the herbicide treatments while the untreated plots had statistically less turf cover than the best performing treatments at 79 percent. No significant differences were found in cover by the predominant grass species, tall fescue and Kentucky bluegrass, for the treatments throughout the experiment (Tables 3 & 4). Initially the cover by tall fescue ranged from 18 to 39 percent and increased slightly over time for most treatments (27 to 46 percent). The one exception was the Plateau combined with PennDOT Custom Blend showing a decrease in tall fescue cover over the course of the experiment (39 to 30 percent). Similarly the cover by Kentucky bluegrass increased over time from an initial cover of 29 to 45 percent and ending in 47 to 67 percent cover at 154 DAT. Overall these cover ratings were not significantly different than the untreated check.

All herbicide treatments significantly reduced the broadleaf weed population. Percent cover by crownvetch was similar for all treatment plots at the beginning of the experiment ranging from 1.4 to 9.5 percent (Table 5). At 154 DAT, the cover by crownvetch was similar for the herbicide treatments (1 to 5 percent) and statistically different from the untreated plots (18.5 percent). The development of chicory was also prevented by the herbicide treatments and at 154 DAT cover by these plants within the treated areas ranged from 0 to 0.1 percent; whereas, the untreated check had an average of 0.7 percent cover (Table 6).

CONCLUSIONS

Both Plateau and Panoramic in combination with either broadleaf weed control component (i.e., Perspective or PennDOT Custom Blend) performed equally well compared to the standard Embark, Escort XP, plus Milestone treatment. It appears that rates of 2 oz/ac Plateau or Panoramic are sufficient to provide turf growth suppression of tall fescue and Kentucky bluegrass with spring-applied treatments. All herbicide treatments showed relative safety to the turf causing initial but transient injury symptoms; significant seed head reduction; and equivalent broadleaf weed control.

MANAGEMENT IMPLICATIONS

All of the treatments tested in this experiment are labeled for suppression of cool-season roadside turf and broadleaf weed control. These herbicide combinations offer alternative tank mixes to PennDOT's plant growth regulation (7711-03) program. A spring application, just prior to seedhead emergence, appears to prevent seedhead development of the predominant turfgrass species without reducing overall turfgrass cover and manages undesirable broadleaf weeds. With a properly timed application the number of mowing cycles can be reduced in areas where mechanical operations are difficult or dangerous. Caution should be used when adding either Perspective or Method, the primary component found in PennDOT Custom Blend, as these products are soil active and have the potential to injure some desirable tree species.

Table 1. Phytotoxicity and percent seedhead suppression of the turf stand. The experiment was visually rated for turf phytotoxicity and seedhead suppression on June 13 and July 11, 2014 (31 and 59 days after treatment, DAT). Treatments were applied on May 13, 2014. All treatments included 0.25% 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 ≤ 0.05.

		turf phytotoxicity (0 to 10 scale)		seedhead suppression percent	
product	rate	31 DAT	59 DAT	31 DAT	59 DAT
	(oz/ac)				
Untreated	----	0 a	0	0 a	0 a
Plateau Perspective	2 3	2.2 ab	0	92 b	94 b
Panoramic Perspective	2 3	3.2 b	0.2	95 b	94 b
Plateau PDT Custom Blend	2 4	3.5 b	0	95 b	95 b
Panoramic PDT Custom Blend	2 4	3.5 b	0	84 b	94 b
Embark Escort XP Milestone	6 0.2 5	3.0 b	0	95 b	97 b
Sign. Level (p≤0.05)		0.004	n.s.	0.000	0.000

Table 2. Percent cover by turfgrass species. The experiment was visually rated for cover by all turfgrass species on May 13, June 13, July 11, September 12, and October 14, 2014 (0, 31, 59, 122, and 154 days after treatment, DAT). Treatments were applied on May 13, 2014. All treatments included 0.25% 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 ≤ 0.05.

		percent cover turfgrass				
product	rate	0 DAT	31 DAT	59 DAT	122 DAT	154 DAT
	(oz/ac)					
Untreated	----	64	58	52 a	74 a	79 a
Plateau Perspective	2 3	54	64	65 ab	86 ab	84 ab
Panoramic Perspective	2 3	70	65	75 b	94 b	96 b
Plateau PDT Custom Blend	2 4	69	68	76 b	94 b	97 b
Panoramic PDT Custom Blend	2 4	56	64	72 ab	91 b	91 ab
Embark Escort XP Milestone	6 0.2 5	70	71	78 b	93 b	97 b
Sign. Level (p≤0.05)		n.s.	n.s.	0.018	0.002	0.005

Table 3. Percent cover by tall fescue (*Festuca arundinacea*, FESAR). The experiment was visually rated for cover by tall fescue on May 13, June 13, July 11, September 12, and October 14, 2014 (0, 31, 59, 122, and 154 days after treatment, DAT). Treatments were applied on May 13, 2014. All treatments included 0.25% 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 ≤ 0.05.

		percent cover tall fescue (FESAR)				
product	rate	0 DAT	31 DAT	59 DAT	122 DAT	154 DAT
	(oz/ac)					
Untreated	----	18	25	22	29	32
Plateau Perspective	2 3	17	18	20	21	27
Panoramic Perspective	2 3	37	32	38	46	46
Plateau PDT Custom Blend	2 4	39	29	33	29	30
Panoramic PDT Custom Blend	2 4	23	16	24	29	31
Embark Escort XP Milestone	6 0.2 5	33	28	32	36	42
Sign. Level (p≤0.05)		n.s.	n.s.	n.s.	n.s.	n.s.

Table 4. Percent cover by Kentucky bluegrass (*Poa pratensis*, POAPR). The experiment was visually rated for cover by Kentucky bluegrass on May 13, June 13, July 11, September 12, and October 14, 2014 (0, 31, 59, 122, and 154 days after treatment, DAT). Treatments were applied on May 13, 2014. All treatments included 0.25% 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 ≤ 0.05.

		percent cover Kentucky bluegrass (POAPR)				
product	rate	0 DAT	31 DAT	59 DAT	122 DAT	154 DAT
	(oz/ac)					
Untreated	----	45	32	31	45	47
Plateau Perspective	2 3	36	45	44	62	56
Panoramic Perspective	2 3	32	32	35	46	50
Plateau PDT Custom Blend	2 4	29	38	43	65	67
Panoramic PDT Custom Blend	2 4	32	47	48	61	60
Embark Escort XP Milestone	6 0.2 5	36	43	43	56	54
Sign. Level (p≤0.05)		n.s.	n.s.	n.s.	n.s.	n.s.

Table 5. Percent cover by crownvetch (*Coronilla varia*, CZRVA). The experiment was visually rated for cover by crownvetch on May 13, June 13, July 11, September 12, and October 14, 2014 (0, 31, 59, 122, and 154 days after treatment, DAT). Treatments were applied on May 13, 2014. All treatments included 0.25% 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 ≤ 0.05.

		percent cover crownvetch (CZRVA)				
product	rate	0 DAT	31 DAT	59 DAT	122 DAT	154 DAT
	(oz/ac)					
Untreated	----	2.8	17.8 b	32 b	21 b	18.5 b
Plateau Perspective	2 3	9.5	5.5 a	0.5 a	4.2 a	3.8 a
Panoramic Perspective	2 3	1.8	0.8 a	0.8 a	2.5 a	1.8 a
Plateau PDT Custom Blend	2 4	1.4	0.8 a	0.4 a	2.5 a	1.9 a
Panoramic PDT Custom Blend	2 4	4.8	3.0 a	3.1 a	5.8 a	5.0 a
Embark Escort XP Milestone	6 0.2 5	1.5	0.2 a	0.1 a	1.2 a	1.0 a
Sign. Level (p≤0.05)		n.s.	0.00	0.00	0.00	0.00

Table 6. Percent cover by chicory (*cichorium intybus*, CHIIN). The experiment was visually rated for cover by chicory on July 11, September 12, and October 14, 2014 (59, 122, and 154 days after treatment, DAT). Treatments were applied on May 13, 2014. All treatments included 0.25% 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 ≤ 0.05.

		percent cover chicory (CHIIN)		
product	rate	59 DAT	122 DAT	154 DAT
	(oz/ac)			
Untreated	----	0.5 b	1.1 b	0.7 b
Plateau Perspective	2 3	0 a	0 a	0 a
Panoramic Perspective	2 3	0 a	0 a	0 a
Plateau PDT Custom Blend	2 4	0 a	0 a	0 a
Panoramic PDT Custom Blend	2 4	0 a	0 a	0 a
Embark Escort XP Milestone	6 0.2 5	0.1 ab	0.2 a	0.1 a
Sign. Level (p≤0.05)		0.003	0.000	0.000

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

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 a 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 2014 indicated that the February seeding of Formula N resulted in the greatest average number of switchgrass (0.8) and little bluestem (0.6) plants per sq. ft. In addition the February seeding produced the highest percent WSG coverage at 49% for Formula N seeded plots. The April seeding of Formula N produced the greatest number of Indiangrass plants (0.6) per sq. ft. and the second greatest number of switchgrass (0.4) and little bluestem plants (0.2) per sq.ft. The February and April seedings produced an equivalent average stand density of big bluestem plants (0.7) per sq. ft. For plots seeded to Formula C, the April seeding produced the highest percent cover of crownvetch (33%), followed by August (7%), July (1.7%), and February (0.3%). 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 slow and sometimes difficult to establish.[2] The purpose of this 2009 long-term experiment was

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[1] PennDOT. Pub. 408 Specifications (2007), Section 804 – Seeding and Soil Supplement
[2] Johnson, J.M. et al. 2012. Native Seed Mix Establishment Implementation – Year Four. Roadside Vegetation Management Research – 2012 Report, pp. 16-20.

to compare the establishment of native WSG species over four seeding dates spaced throughout the year to that of crownvetch. This report represents the fifth 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 July 13, 2013, in an effort to control broadleaf weeds, WSG plots were treated with Triplet LO at 64 oz/ac plus 0.25% CWC 90 surfactant, while crownvetch plots were treated with Panoramic 2SL at 6 oz/ac plus 0.25% CWC 90 surfactant. On September 9, 2014, approximately 5 years after the last seeding, all plots were visually evaluated to estimate percent total cover, percent cover by WSG (only native seeded plots), and percent cover by crownvetch. 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 September 9, 2014, 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 3. Approximately 5 years after seeding, plots seeded in February produced the highest percent cover by WSG (49%) followed by plots seeded in April (42%), July (11%), and August (2%). Stem counts for individual WSG species (Table 4) revealed that February and April seedings resulted in the greatest establishment across the five WSG species planted. Plots seeded in February yielded the largest number of switchgrass and little bluestem plants, 0.8, and 0.6 plants per sq. ft., respectively. Big bluestem plants were found in equal numbers (0.7 stems per sq. ft.) in plots seeded in February and April.

April plots yielded the highest number of Indiangrass and Virginia wildrye plants 0.6 and 0.1 per sq. ft. respectively. WSG stem counts were not calculated for plots seeded in August because there were not enough WSG plants present (2% cover) to warrant sampling.

When comparing percent cover by WSG between 2011 and 2014 growing seasons, the most noteworthy difference is that all timings nearly doubled the percentage of cover by WSG in the three-year period.

For plots seeded to crownvetch (Table 5), total cover ranged from a high of 70% for the April seeding to a low of 40% for the February seeding. Also for plots seeded to crownvetch, cover by crownvetch was highest for the April timing (33%), followed by the August timing rated at 7%. This represents a decline in crownvetch cover from data collected in 2012 where crownvetch was reported at 65 and 30 percent cover for April and August seedings, respectively.[3] A thorough description of the site and first, second, and third full year results after seeding can be found at Johnson et al.[3,4,5,6]

CONCLUSIONS

From the data gathered following five 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) which suggest 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 continue to show an increase in WSG stems. 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 cover by WSG nearly doubled in all 4 timings since 2011.

The April and August seeding resulted in the greatest crownvetch establishment. The decrease in crownvetch cover since 2012 may have been due in part to the application of Plateau made in 2013 to help control weed pressure. The greater presence of crownvetch in April and August seeded plots seems reasonable since April environment 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 warm soil temperatures which support greater recovery time for seedlings. Crownvetch remains a more rapid, expansive, and competitive ground cover on poor sites compared to WSG seeding. This is apparent in the quicker establishment after seeding and in the competitive creep of crownvetch into WSG seeded

[3] Johnson et al. 2013. Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Four. Roadside Vegetation Management Research – 2013 Report. pp. 42-47.
[4] 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.
[5] 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.
[6] 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.

sites. Reliance on WSG as a revegetation option requires a commitment to native mixes and a willingness to allow time and provide 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. Since the 2012 growing season, it has become obvious that maintenance such as mowing, applying an herbicide, or both are 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 fasciculate	partridge pea	2	0.4

Table 3. 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 2014 was collected on September 9, 2014, approximately 5 years from the last seeding. 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		2014	
Treatment	Timing	%Total Cover	% Cover by WSG	%Total Cover	% Cover by WSG
Native	Feb	68	25 a	53	49 a
Native	Apr	72	20 ab	55	42 a
Native	Jul	87	1 b	60	11 b
Native	Aug	73	1 b	63	2 bc
		N.S.		N.S	

Table 4. Stem counts for plots seeded to warm season grasses (WSG). Seeding occurred February 13, April 23, July 7, and August 21, 2009. Data was recorded on September 9, 2014, approximately 5 years 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	0.3 ab	0.7 a	0.8 a	0.07	0.6 a
Native	Apr	0.6 a	0.7 a	0.4 b	0.1	0.2 ab
Native	Jul	0.07 b	0.1 b	0.03 c	0.03	0.1 b
Native	Aug	0 b	0 b	0 c	0	0 b
					N.S.	

Table 5. Cover ratings for plots seeded to Formula C, crownvetch. Seeding occurred February 13, April 23, July 7, and August 21, 2009. Data was recorded on September 9, 2014, approximately 5 years 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	% Total Cover	% Cover by Crownvetch
Crownvetch	February	40	0.3
Crownvetch	April	70	33
Crownvetch	July	53	1.7
Crownvetch	August	53	7
		N.S.	N.S.

INVESTIGATING GRASS SPECIES, SEEDING RATES, AND FERTILIZER PLUS BROADLEAF HERBICIDE APPLICATION FOR GROUNDCOVER ESTABLISHMENT IN ROADSIDE APPLICATIONS

Herbicide trade and common names: Escort XP (*metsulfuron*), Roundup Pro Max (*3.7 lb ae glyphosate/gal*); Method (*aminocyclopyrachlor*), PennDOT Custom Blend (*aminocyclopyrachlor* + *metsulfuron*).
Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), creeping red fescue (*Festuca rubra* L.), foxtail fescue (*Vulpia myuros*), hard fescue (*Festuca brevipila*), orchardgrass (*Dactylis glomerata* L., var. 'Maintain'), sheep fescue (*Festuca ovina* L., var. 'Whisper').

ABSTRACT

The success of a vegetation management program in the roadside environment relies heavily on the use of competitive groundcovers. A successful groundcover should develop quickly, provide a dense stand, prevent unwanted weeds, require minimal maintenance, and survive under harsh environmental conditions and poor soils. Formula L, a combination of hard fescue, creeping red fescue, and annual ryegrass at 55, 35, and 10 percent by weight, respectively, is a standard PennDOT seed mix. This experiment compared the doubling of the previous standard Formula L seeding rate of 24 lb/1000 sq. yards (SY) to the newly established standard rate of 48 lb/1000 SY in their ability form a complete cover during establishment. In addition, three new species (i.e. two perennial species, 'Whisper' sheep fescue and 'Maintain' orchardgrass, and one annual species, foxtail fescue) were seeded to evaluate the effectiveness in establishing under roadside conditions as a possible addition to future roadside seed mixes. The seeding treatments included a split block overlay in which supplemental fertilizer and a broadleaf herbicide were applied to half of each of the seeded plots during the first season of establishment to determine their effect on establishment.

Both rates of Formula L and sheep fescue established equally well. The variety of orchardgrass and seeding rate tested in this experiment did not provide the cover observed with the fine fescues (Formula L or sheep fescue). Foxtail fescue did not demonstrate utility as a stand-alone species for seeding on the roadside but could be further investigated as an annual component in seed mixes for roadside application. Fertilizer and broadleaf herbicide applications were effective in encouraging grass stand development; however, these effects were transient and diminished by the following growing season.

INTRODUCTION

The establishment of a competitive groundcover in the roadside environment is crucial to slowing natural succession and providing a manageable plant community. Grasses are often the best-suited groundcover in these situations. Grass allows for easier maintenance through periodic mowing and/or selective broadleaf weed control. Selecting grass species that will survive and remain vigorous in harsh environments is imperative. The soil and environmental conditions that exist along a road are often poor. One combination of turf species that is well suited for the roadside and is currently used by PennDOT in both construction and revitalization projects is referred to as 'Formula L'. This mix consists of hard fescue, creeping red fescue, and annual ryegrass. Seeding rate recommendations can vary, although the PennDOT Maintenance Manual, Pub 408, Section 804 currently suggests 48 lb/1000 sq. yards (SY) previous recommendations were 24 lb/1000 SY. Foxtail fescue, an annual grass species, and two perennial species, 'Maintain' orchardgrass and sheep fescue have been promoted as short in height, drought tolerant, and hardy.[1] This experiment compared the seeding rates of Formula L and examined the ability of the new species for establishing under roadside conditions. In addition, the effect and potential benefit of a supplemental fertilizer and a broadleaf herbicide application during the first year of establishment was also examined.

MATERIALS AND METHODS

The experiment was established at two separate locations. The first (site 1) was located on the shoulder of SR 322E, near Philipsburg, PA. Formula L was seeded at rates of 24 and 48 lb/1000 SY, 'Whisper' sheep fescue at 6 lb/1000 sq ft., 'Maintain' orchardgrass at 12 lb/ac, and foxtail fescue at 12 lb/ac. Plots 15 by 24 feet in size were arranged in a randomized complete block design with four replications. Plots were initially sprayed with a 1.5% v/v solution of Roundup Pro Max to eliminate all existing vegetation on September 20, 2013. The entire site was disced on September 30, 2013. Seed and soil supplements were applied on October 4, 2013. Plots were fertilized according to soil test recommendations at a rate of 1 lb N, 5 lb P_2O_5, 0.5 lb K_2O, and 70 lb pelletized lime per 1000 sq ft. An erosion control blanket was also installed across the entire site on the same date as seed and soil supplements were applied. The following season, on July 7, 2014, one half of each plot was fertilized using an 18-5-9 fertilizer to achieve 1 lb N/1000 sq ft. On August 8, 2014 an application of 4 oz/ac PennDOT Custom Blend herbicide (equivalent to 3.84 oz/ac Method + 0.16 oz/ac Escort XP) plus 0.25 percent v/v non-ionic surfactant was applied in 35 gallons per acre carrier to the same half of each plot.

Percent cover by desirable grasses was evaluated on June 20 and September 15, 2014 and June 8, 2015 (8, 11 and 20 months after seeding, MAS, respectively). Additionally, percent cover by weeds was rated on September 15, 2014 and June 8, 2015 (11 and 20 MAS, respectively). 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.

The second experiment (site 2) was located at Penn State University's Landscape Management Research Center, University Park, PA. Only the two seeding rates of Formula L were investigated at this site. Plots 9 by 8 feet in size were arranged in a randomized complete block design with four replications. Plots were initially sprayed with a glyphosate to eliminate all existing vegetation and several weeks later on October 9, 2013, the entire site was disced. Seed and soil supplements were applied on October 10, 2013. Plots were fertilized according to soil test recommendations at a rate of 1 lb N, 0.5 lb P_2O_5, 2 lb K_2O, and 70 lb pelletized lime per 1000 sq ft. Straw mulch was also applied at a rate of 1200 lb/1000 SY across the entire site on the same date as seed and soil supplements were applied. The following season, on July 7, 2014, one half of each plot was fertilized using an 18-5-9 fertilizer to achieve 1 lb N/1000 sq ft. On August 8, 2014 an application of 4 oz/ac PennDOT Custom Blend herbicide plus 0.25 percent v/v non-ionic surfactant was applied in 35 gallons per acre carrier to the same half of each plot.

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[1] AshlyAnn Lemhouse, personal communication, July 25, 2013.

Percent cover by desirable turf was evaluated on June 19 and September 16, 2014 and June 9, 2015 (8, 11, and 20 months after seeding, MAS, respectively). Additionally, percent cover by weeds was rated on September 16, 2014 and June 9, 2015 (11 and 20 MAS, respectively). 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

Site 1

The percent cover by desirable grasses was the highest and comparable for both rates of Formula L and the sheep fescue at all rating dates (Table 1). On June 2014 the Formula L and sheep fescue ranged from 60 to 69 percent cover. Cover by orchardgrass and foxtail fescue was recorded at 15 and 24 percent, respectively. The supplemental fertilizer and broadleaf herbicide applications resulted in a significant increase in percent cover for both the Formula L seeding treatments and the sheep fescue plots increasing from 60 to 69 percent cover to 90 to 96 percent cover. A similar increase in cover was found with both orchardgrass and foxtail fescue. Cover by orchardgrass increased from 44 to 72 percent, while foxtail fescue increased from 2 to 45 percent. By June 2015, the level of stand cover increased slightly from the September 2014 evaluation for all seeding treatments where supplemental fertilizer and a broadleaf herbicide weed applications were not applied, except for the orchardgrass plots. Both rates of Formula L and sheep fescue ranged from 68 to 78 percent cover; whereas, orchardgrass and foxtail fescue were found to have 32 and 9 percent cover, respectively. The fertilizer and broadleaf herbicide applied the previous season appeared no longer effective by the June 2015 rating. Formula L cover ranged from 57 to 77 percent for both seeding rates with no significant differences, while sheep fescue cover ranged from 78 to 87 percent. Orchardgrass had produced less cover (32 to 46 percent) compared to both Formula L rates and sheep fescue while foxtail fescue had the least cover (9 to 23 percent).

Weeds were greatly reduced within all seeded plots following the broadleaf herbicide application conducted in August 2014 (Table 2). Weed populations were reduced to 1 or 2 percent for all seeding treatments, except foxtail fescue. The orchardgrass and foxtail fescue treatments which initially had the highest weed cover ratings were the only species to show a statistically significant reduction in weed cover at the September 2014 and June 2015 ratings . The weed cover in the orchardgrass plots fell from 37 to 1 percent in September 2014 with little change by June 2015 (38 to 2 percent). Cover by weeds in the foxtail fescue fell from 66 to 14 percent in September 2014 with little change by June 2015 (61 to 16 percent).

Site 2

The percent turf cover was comparable at the June 2014 and June 2015 rating periods for both Formula L seeding rates among plots regardless of a supplemental fertilizer and broadleaf herbicide treatment (Table 3). The percent desirable turf cover was significantly different between the 24 lb and 48 lb/1000 SY seeding rates at the September 2014 rating. On June 2014 the Formula L rating was 49 and 57 percent cover for the 24 and 48 lb/1000 SY treatments, respectively. The supplemental fertilizer and broadleaf herbicide application to half of the plots resulted in a significant increase in percent cover for both seeding rates (i.e. 24 and 48 lb/1000

SY) by the September 2014 rating period with 72 and 84 percent cover among plots not supplemented to 96 and 97 percent cover for supplemented plots. By June 2015, turf cover increased for both seeding rates in plots where no supplemental fertilizer and broadleaf herbicide were applied. However, both rates of Formula L with or without supplemental fertilizer and broadleaf herbicide were statistically similar and ranged from 88 to 92 percent cover. The effect of the supplemental fertilizer and broadleaf herbicide applications did not carry over to the beginning of the second growing season.

Weeds were greatly reduced within all seeded plots following the broadleaf herbicide application applied in August 2014 (Table 4). Weed populations were reduced to 1 percent for both seeding rates by September 2014 where this treatment was applied. However, by June 2015 all plots had similar weed cover ratings ranging from 0 to 2 percent.

CONCLUSIONS

Both rates of Formula L and sheep fescue established equally well. Formula L applied at either 24 or 48 lb/1000 SY provided significant initial cover that remained for the duration of these evaluations. The establishment of sheep fescue actually exceeded that of Formula L where supplemental fertilizer and broadleaf herbicide were applied by the last rating date. The variety of orchardgrass and seeding rate tested in this experiment did not provide the cover observed with the fine fescues (Formula L or sheep fescue). Orchardgrass has a few drawbacks for use in roadside applications: 1) it is a bunch-type grass that would require another component within a seed mix to establish in the voids created by this growth habit; 2) it grows taller in comparison to the fine fescues, requiring mowing; 3) as a forage grass it may attract wildlife to the roadside; and 4) plant growth regulators have been observed to be less effective on this species. Foxtail fescue is an annual grass that has not demonstrated utility as a stand-alone species for seeding on the roadside. It did show some encouraging signs of development where supplemental fertilizer and a broadleaf herbicide application were applied during the establishment phase. Perhaps, foxtail fescue would have utility as an annual component in a seed mix for roadside application, but advantages over annual ryegrass would first have to be demonstrated in future studies. Supplemental fertilizer and broadleaf herbicide applications are effective in encouraging a developing grass stand, but these effects are transient and diminished by the following growing season.

MANAGEMENT IMPLICATIONS

Even though seeding Formula L at 24 lb/1000 SY was successful on these sites, the 48 lb/1000 SY rate of Formula L provides a greater assurance of cover where soil and site conditions are unfavorable to seed germination and establishment. Sheep fescue may have merit for difficult sites with poor soil quality; however further experiments would be necessary before recommendations could be made.

Sites that are designated for seeding should receive the proper soil supplements at the time of seeding. The use of fertilizer and weed control during the establishment phase is suggested. This will encourage the developing grasses and offer them a competitive advantage in most situations; however it must be recognized that the boost provided will be transient.

Table 1. Percent cover by desirable grasses (Site 1). The trial was visually rated for percent cover by desirable (seeded) grasses on June 20 and September 15, 2014 and June 8, 2015 (8, 11, and 20 months after seeding, MAS, respectively). The experiment was seeded, fertilized, and straw mulched on October 4, 2013. Fertilizer and broadleaf herbicide was applied to half of each plot on July 7 and August 8, 2014, respectively. Each value is the mean of four replications. Means within similarly shaded areas followed by the same letter are not significantly different at $p \leq 0.05$.

seed mix	Rate	Percent Cover by Desirable Species				
		June 2014	Sept 2014		June 2015	
			no fert/bl	fert/bl	no fert/bl	fert/bl
Formula L (1X)	24 lb/1000 SY	60 b	62 c	96 d	68 cde	57 cd
Formula L (2X)	48 lb/1000 SY	69 b	69 c	96 d	77 de	60 cd
Sheep Fescue	16 lb/1000 SF	60 b	60 bc	90 d	78 de	87 e
Orchardgrass	12 lb/ac	15 a	44 b	72 c	32 b	46 bc
Foxtail Fescue	12 lb/ac	24 a	2 a	45 b	9 a	23 ab

Table 2. Percent cover by weeds (Site 1). The trial was visually rated for percent cover by weeds on September 15, 2014 and June 8, 2015 (11 and 20 months after seeding, MAS, respectively). The experiment was seeded, fertilized, and straw mulched on October 4, 2013. Fertilizer and broadleaf herbicide was applied to half of each plot on July 7 and August 8, 2014, respectively. Each value is the mean of four replications. Means within similarly shaded areas followed by the same letter are not significantly different at $p \leq 0.05$.

seed mix	Rate	Percent Cover by Weeds			
		Sept 2014		June 2015	
		no fert/bl	fert/bl	no fert/bl	fert/bl
Formula L (1X)	24 lb/1000 SY	21 ab	1 a	8 a	1 a
Formula L (2X)	48 lb/1000 SY	20 ab	1 a	8 a	1 a
Sheep Fescue	16 lb/1000 SF	22 ab	2 a	10 a	1 a
Orchardgrass	12 lb/ac	37 bc	1 a	38 bc	2 a
Foxtail Fescue	12 lb/ac	66 c	14 ab	61 c	16 ab

Table 3. Percent cover by desirable turf (Site 2). The trial was visually rated for percent cover by desirable (seeded) turf on June 19 and September 16, 2014 and June 9, 2015 (8, 11, and 20 months after seeding, MAS, respectively). The experiment was seeded, fertilized, and straw mulched on October 10, 2013. Fertilizer and broadleaf herbicide was applied to half of each plot on July 7 and August 8, 2014, respectively. Each value is the mean of four replications. Means within similarly shaded areas followed by the same letter are not significantly different at $p \leq 0.05$.

seed mix	Rate	Percent Cover by Desirable Turf				
		June 2014	Sept 2014		June 2015	
			no fert/bl	fert/bl	no fert/bl	fert/bl
Formula L (1X)	24 lb/1000 SY	49 a	72 a	96 c	91 a	88 a
Formula L (2X)	48 lb/1000 SY	57 a	84 b	97 c	92 a	90 a

Table 4. Percent cover by weeds (Site 2). The trial was visually rated for percent cover by weeds on September 16, 2014 and June 9, 2015 (11 and 20 months after seeding, MAS, respectively). The experiment was seeded, fertilized, and straw mulched on October 10, 2013. Fertilizer and broadleaf herbicide was applied to half of each plot on July 7 and August 8, 2014, respectively. Each value is the mean of four replications. Means within similarly shaded areas followed by the same letter are not significantly different at $p \leq 0.05$.

seed mix	Rate	Percent Cover by Weeds			
		Sept 2014		June 2015	
		no fert/bl	fert/bl	no fert/bl	fert/bl
Formula L (1X)	24 lb/1000 SY	22 c	1 a	2 a	0 a
Formula L (2X)	48 lb/1000 SY	8 b	1 a	1 a	0 a

COMPARING ESPLANADE BAREGROUND TANK MIXES WITH PLATEAU FOR SEASON-LONG WEED CONTROL

Herbicide trade and common names: Derigo (*foramsulfuron + iodosulfuron + thiencarbazone*); Diuron 80 (*diuron*); Escort XP (*metsulfuron*); Esplanade (*indaziflam*); Journey (*glyphosate + imazapic*); MAT28, Method (*aminocyclopyrachlor*); Matrix (*rimsulfuron*); Milestone VM (*aminopyralid*); Oust Extra (*sulfometuron + metsulfuron*); Oust XP (*sulfometuron*); Perspective (*aminocyclopyrachlor + chlorsulfuron*); Plateau (*imazapic*); Razor Pro, Accord XRTII (*glyphosate*); Streamline, Custom Blend (*aminocyclopyrachlor + metsulfuron*); Viewpoint (*aminocyclopyrachlor + metsulfuron + imazapyr*).

Plant common and scientific names: common evening primrose (*Oenothera biennis*); marestail (*Conyza canadensis*); prostrate spurge (*Euphorbia supina*); spotted knapweed (*Centaurea maculosa*).

ABSTRACT

Guiderails, signposts, and other structures found along the road require annual herbicide treatments to maintain bareground and ensure unimpeded flow of water, improved visibility and access, and enhanced aesthetics. Herbicide applications to prevent vegetation are a cost effective approach compared to mechanical control or installing physical barriers. There are a variety of herbicides and combinations labeled for this application. Esplanade is a preemergence herbicide that has shown promise as a tank mix partner in previous work. Esplanade was applied in numerous tank mix combinations to evaluate season-long vegetation control and in comparison with Plateau a bareground preemergence component.

Most tank mixes and rates tested in this experiment offered excellent long-term weed control for the plant species encountered. Weed development was inhibited using Esplanade combined with Derigo, *aminocyclopyrachlor* (e.g., Viewpoint, Streamline, Perspective, or Custom Blend), or Milestone VM and the standard, Diuron combined with Oust Extra based on visual ratings of 97 to 100 percent bareground at 150 days after treatment, DAT. Spotted knapweed did establish in plots treated with a mix of Esplanade combined with Plateau or Matrix, while prostrate spurge developed in plots where tank mixes of Plateau in combination with Perspective, Streamline, or Custom Blend were applied.

INTRODUCTION

The areas beneath guiderails and around signposts are often sprayed with an herbicide mixture early in the growing season to prevent vegetation growth throughout the year. The advantages of maintaining these areas vegetation free include facilitating traveler sight distance and access for maintenance, improving drainage, enhancing aesthetics, and reducing maintenance costs. There are many tank mixes currently available to provide these benefits but continued testing of products, combinations, and rates decreases weed resistance development and assures active ingredient rotation opportunities are available to vegetation managers. This experiment compares a variety of tank mix combinations for their efficacy in providing bareground weed control throughout the season. Generally, a bareground herbicide mixture will include a preemergence, broadspectrum residual, and postemergence component. Esplanade (i.e., indaziflam) has been evaluated and showed promise as a preemergence component in bareground tank mixes in previous experiments.[1,2,3] In this experiment several products were partnered with Esplanade to determine whether the combinations and rates would offer season-long weed control. The tank mix partners included: Oust, Derigo, Matrix, Viewpoint, Streamline, Perspective, Custom Blend, or Milestone VM. Derigo is new to the marketplace and was introduced by Bayer CropScience LP in October 2014. This product is a combination of three active ingredients and described as having both postemergence and short-term preemergence activity. Custom Blend is a combination of 7.67 oz Method and 0.33 oz Escort at an 8 oz. product rate. In addition, the herbicide Plateau was compared to Esplanade in combination with products containing *aminocyclopyrachlor* (i.e., Perspective, Streamline, and Custom Blend).

MATERIALS AND METHODS

The experimental site was located along I-99 southbound near Tyrone, PA. Treatments included Razor Pro alone at 64 oz/ac; Esplanade at 5 oz/ac combined with Oust XP at 3 oz/ac, Derigo at 3 or 6 oz/ac, Plateau at 8 oz/ac, Matrix at 4 oz/ac, Viewpoint at 13 or 16 oz/ac, Streamline at 8 oz/ac (with and without Oust XP at 3 oz/ac), Perspective at 8 oz/ac, or Custom Blend at 8 oz/ac; Esplanade at 5 oz/ac combined with Custom Blend at 8 oz/ac and Plateau at 8 oz/ac; Esplanade at 5 oz/ac combined with Custom Blend at 8 oz/ac, Journey at 32 oz/ac and Razor Pro at 48 oz/ac; Esplanade at 5 oz/ac combined with Custom Blend at 8 oz/ac and Oust Extra at 3 oz/ac; Plateau at 12 oz/ac combined with Perspective, Streamline, or Custom Blend at 8 oz/ac; Esplanade at 5 oz/ac combined with Milestone VM at 7 oz/ac and Escort XP at 1 oz/ac; Diuron at 128 oz/ac and Oust Extra at 4 oz/ac; and an untreated check. Razor Pro was added to all herbicide treatments at 64 oz/ac, except the Esplanade combined with Custom Blend, Journey, and Razor Pro since this treatment included glyphosate. Accord XRTII was added at 48 oz/ac to two treatments including Plateau at 12 oz/ac combined with Custom Blend at 8 oz/ac and Esplanade at 5 oz/ac combined with Milestone VM at 7 oz/ac and Escort XP at 1 oz/ac instead of Razor Pro due to a shortage of material on hand during mixing. A non-ionic surfactant (i.e., Induce) was added to all herbicide treatments at 0.25% v/v. Treatments were applied at an application rate of 50 gallons per acre. The experiment was established as a randomized complete block design with four replications. Plots were 20 by 6 ft. in size. Treatments were applied on April 24, 2014 using a CO_2-powered sprayer operating at 38 psi and equipped with either a single BoomJet XP 20L tip for reps 2-4 or six ft boom equipped with (4) 8004VS tips for rep 1. The first significant rainfall following treatment occurred on May 15, 2014 with 0.28 inches according to http://www.wunderground.com.

The experiment was visually rated for percent bareground and cover by spotted knapweed on April 25, May 23, June 23, July 23, August 22, and September 22, 2014, 1, 28, 59, 89, 119, and 150 days after treatment, DAT. Ratings for percent cover by marestail, common evening primrose, and prostrate spurge were recorded on July 23, August 22, and September 22, 2014,

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[1] Johnson et al. 2012. Indaziflam as a Preemergence Component in a Bare Ground Weed Control Program. Roadside Vegetation Management Research Report – 2012 Report. pp. 24-27.

[2] Johnson et al. 2013. Evaluation of Indaziflam, Pendimethalin, and Prodiamine in Tank Mixes for Bareground Weed Control. Roadside Vegetation Management Research Report – 2013 Report. pp. 48-52.

[3] Johnson et al. 2014. Evaluating the Efficacy of Esplanade in Bareground Tank Mixes and Compared to Proclipse, Pendulum EC, and Diuron. Roadside Vegetation Management Research Report – 2014 Report. pp. 41-47.

89, 119, and 150 DAT. Only percent bareground and cover by spotted knapweed data collected at 150 DAT is reported (Table 1).

RESULTS AND DISCUSSION

Percent bareground within the plots ranged from 97 to 100 and spotted knapweed cover ranged from 0 to 3 percent at the onset of the experiment. By September 22 (150 DAT) the Razor Pro only treatment, treatments containing Plateau combined with a single product, and tank mixes of Esplanade combined with Oust XP or Matrix were statistically similar to the untreated check (89 percent) with values of 88 to 97 percent bareground. All other treatments ranged from 97 to 100 percent bareground and were significantly different than the control. Spotted knapweed was the species found in the greatest abundance within the experimental area. Most herbicide treatments reduced spotted knapweed cover at 150 DAT (0 to 2.4 percent) compared to the untreated check (6.5 percent). However, two treatments, Razor Pro alone (3.1 percent) and the Esplanade plus Plateau treatment (3 percent), were similar to the untreated check and less effective at controlling spotted knapweed. Prostrate spurge appeared in most plots treated with tank mixes containing Plateau.

CONCLUSIONS

Most tank mixes and rates tested in this experiment offered excellent long-term weed control for the plant species encountered at this site. Weed development was greatly inhibited using Esplanade combined with Derigo, *aminocyclopyrachlor* (e.g., Viewpoint, Streamline, Perspective, or Custom Blend), or Milestone VM and the standard, Diuron combined with Oust Extra. Notable exceptions, that did not provide comparable weed control, were Razor Pro alone, mixes containing Plateau combined with a single product, and Esplanade combined with Oust XP or Matrix. In particular, Esplanade combined with Plateau or Matrix allowed for the establishment of spotted knapweed. Plateau in combination with Perspective, Streamline, or Custom Blend did not prevent prostrate spurge from establishing.

MANAGEMENT IMPLICATIONS

Tank mixes of Esplanade combined with products containing either *aminocyclopyrachlor* (e.g., Viewpoint, Streamline, Perspective, or Custom Blend) or Milestone VM at the rates evaluated in this experiment will offer excellent weed control for a host of common weed species in roadside bareground areas. Caution is advised with the use of products containing *aminopyralid* or *aminocyclopyrachlor* where concerns exist for uptake of these materials by the root system of trees within the right-of-way. While Esplanade plus Derigo was effective in this instance, additional testing in various environments should be conducted to further document its effectiveness. Plateau in combination with Perspective, Streamline, or Custom Blend remains an option in a rotation for guiderail treatments where some weed development can be tolerated.

Table 1. Percent bareground and cover by spotted knapweed (*Centaurea maculosa, CENMA*). The trial was visually rated for percent bareground and cover by CENMA on September 22, 2014, 150 days after treatment, DAT. Treatments were applied on April 24, 2014. All herbicide treatments included 0.25 percent v/v non-ionic surfactant and 1.5 lb ae/ac *glyphosate*. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

product	rate	percent bareground	percent knapweed cover	product	rate	percent bareground	percent knapweed cover
	(oz/ac)	9/22/14	9/22/14		(oz/ac)	9/22/14	9/22/14
untreated	---	89 ab	6.5 b	Esplanade Viewpoint	5 13	100 d	0.1 a
Razor Pro	64	88 a	3.1 ab	Esplanade Custom Blend	5 8	100 d	0 a
Esplanade Oust XP	5 3	97 bcd	1.4 a	Esplanade Custom Blend Plateau	5 8 8	100 d	0 a
Esplanade Derigo	5 3	98 cd	2 a	Esplanade Custom Blend Journey Razor Pro	5 8 32 48	99 d	0 a
Esplanade Derigo	5 6	97 cd	1.8 a	Esplanade Custom Blend Oust Extra	5 8 3	99 d	0.3 a
Esplanade Plateau	5 8	94 a-d	3 ab	Esplanade Perspective	5 8	98 cd	0 a
Esplanade Matrix	5 4	97 bcd	2.4 a	Plateau Perspective	12 8	94 a-d	0.9 a
Esplanade Viewpoint	5 16	100 d	0 a	Plateau Streamline	12 8	93 a-d	1.5 a
Esplanade Streamline	5 8	99 cd	0.8 a	Plateau Custom Blend	12 8	91 abc	1.5 a
Esplanade Streamline Oust XP	5 8 3	100 d	0 a	Esplanade Milestone VM Escort XP	5 7 1	99 cd	0.1 a
Diuron Oust Extra	128 4	97 cd	0.7 a				