Roadside Vegetation Management Research – 2012 Report

ANNUAL REPORT

June 30, 2012

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

THE PENNSYLVANIA STATE UNIVERSITY

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

Purchase Order No: 4300312816
Purchase Order Description:
Master Agreement # 4400008014

Technical Report Documentation Page

1. Report No. PA-2012-007-PSU RVM 4300312816	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Roadside Vegetation Management Research – 2012 Report		**5. Report Date** June 30, 2012 **6. Performing Organization Code**
7. Author(s) Jon M. Johnson, David A. Despot, and James C. Sellmer.		**8. Performing Organization Report No.**
9. Performing Organization Name and Address The Pennsylvania State University College of Agricultural Sciences University Park, PA 16802		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** Purchase Order No: 4300312816
12. Sponsoring Agency Name and Address The Pennsylvania Department of Transportation Bureau of Planning and Research Commonwealth Keystone Building 400 North Street, 6th Floor Harrisburg, PA 17120-0064		**13. Type of Report and Period Covered** Annual Report: July 1, 2011 – June 30, 2012 **14. Sponsoring Agency Code**
15. Supplementary Notes Project Management – Joseph S. Demko – Bureau of Maintenance and Operations, Office of Roadside Development		
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: Comparison of Herbicides and Mowing Regimes for Control of Canada Thistle in a Grass Groundcover, Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Three, Evaluation of Native Seed Mixes for Roadside Application, Native Seed Mix Establishment Implementation – Year Four, Slopemaster Seed Mix Demonstration, Indaziflam as a Preemergence Component in a Bareground Weed Control Program, MAT28 in Combination with Preemergence Herbicides for Season-Long Bareground Weed Control.		
17. Key Words Roadside vegetation management, herbicides, herbaceous weed control, Canada thistle, warm-season grass, native seed mix, Slopemaster, bareground, indaziflam, MAT28, aminocyclopyrachlor		**18. Distribution Statement** No restrictions. This document is available from the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	**20. Security Classif. (of this page)**	**21. No. of Pages**	**22. Price**
Unclassified	Unclassified	38	

Form DOT F 1700.7 **(8-72)** **Reproduction of completed page authorized**

ACKNOWLEDGMENTS

This research was funded by the Pennsylvania Department of Transportation, Bureau of Maintenance and Operations, and conducted by the Department of Horticulture, of the College of Agricultural Sciences at Penn State. Personnel contributing to the production of this report include Jon M. Johnson, research support associate; David A. Despot, research support associate; and James C. Sellmer, professor of ornamental horticulture at Penn State.

The authors would like to begin by thanking the PennDOT District Roadside Specialists who have been instrumental in locating the field sites needed for this research. Our sincere appreciation goes to Joseph S. Demko for his support of this research project. We also thank Tracey Harpster, research support technician, and Kirsten Lloyd for their invaluable assistance.

We are grateful for the assistance of the representatives of the various manufacturers providing products for the vegetation management industry, who have lent their time, expertise, and material support on many occasions. The following manufacturers assisted this research project during the 2011 season: E.I. DuPont de Nemours & Co. and Bayer Environmental Science.

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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

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

Product Information Referenced in This Report

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

Trade Name	Active Ingredients	Formulation	Manufacturer
Authority	sulfentrazone	75 WDG	E.I. DuPont de Nemours & Co.
Escort XP	metsulfuron methyl	60 WDG	E.I. DuPont de Nemours & Co.
Esplanade	indaziflam	200 SC	Bayer Environmental Science
Goal 2XL	oxyfluorfen	2 EC	Dow AgroSciences LLC
Karmex XP	diuron	80 WDG	E.I. DuPont de Nemours & Co.
Krovar I	bromacil + diuron	40 + 40 WDG	E.I. DuPont de Nemours & Co.
MAT28	aminocyclopyrachlor	50 WDG	E.I. DuPont de Nemours & Co.
Matrix	rimsulfuron	25 WDG	E.I. DuPont de Nemours & Co.
Milestone VM	aminopyralid	2 S	Dow AgroSciences LLC
Oust XP	sulfometuron	75 WDG	E.I DuPont de Nemours & Co.
Overdrive	dicamba + diflufenzopyr	70 WDG	BASF Specialty Products
Payload	flumioxazin	51 WDG	Valent U.S.A. Corporation
PennDOT Custom Blend	aminocyclopyrachlor + metsulfuron	47.9 + 2.5 DF	E.I. DuPont de Nemours & Co.
Pendulum	pendimethalin	3.3 EC	BASF Specialty Products
Perspective	aminocyclopyrachlor + chlorsulfuron	39.5 + 15.8 DF	E.I. DuPont de Nemours & Co.
Prowl	pendimethalin	3.3 EC	BASF Specialty Products
Roundup Pro Max	glyphosate	5.5 S	Monsanto Company
Roundup Original Max	glyphosate	5.5 S	Monsanto Company
Specticle	indaziflam	20 WSP	Bayer Environmental Science
Streamline	aminocyclopyrachlor + metsulfuron	39.5 + 12.6 DF	E.I. DuPont de Nemours & Co.
Surflan AS	oryzalin	4 F	United Phosphorus, Inc.
Triplet LO	2,4-D + mecoprop-p + dicamba	47.3 + 8.2 + 2.3 S	NuFarm Americas, Inc.
Valor	flumioxazin	51 WDG	Valent U.S.A. Corporation

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 (2*,4-D + mecoprop-p + dicamba*).
Plant common and scientific names: Canada thistle (*Cirsium arvense*).

ABSTRACT

Canada thistle is a troublesome perennial species and a recognized Pennsylvania and federal noxious weed. It has a tremendous capacity to reproduce from seed and spread through a deep and wide spreading root system. In the past, mowing alone has been used to prevent seeding; however, mowing did not control the spreading root system allowing for underground colony spread. Once mowing levels were reduced in response to energy costs, Canada thistle responded with greater colony size and prolific flowering and seeding. A combination of early season mowing and late season herbicide application can be an effective control strategy but may involve treatments over multiple seasons. In an effort to develop an efficient and cost effective Canada thistle management program, a long term study consisting of a spring treatment of either mowing or herbicide treatment (chemical mowing), followed by a fall mowing or application of Milestone VM, combinations of Milestone VM + Overdrive, or combinations of Perspective + Overdrive was undertaken in the fall of 2010. Two sites, 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 study. Initial cover by Canada thistle was 5.5% and 44% at the Mountville and Indiana sites, respectively. Approximately one year after initial treatment (373 days after initial treatment, DAIT, for the Mountville site and 363 DAIT for the Indiana site), all treatment sequences reduced Canada thistle populations relative to initial ratings. At one year after treatment, the number of Canada thistle stems per plot was significantly lower at the Indiana site for plots treated with a fall herbicide application as compared to fall mowing. While it appears that the treatments were effective at reducing Canada thistle within a groundcover comprised primarily of grasses, results are preliminary and further treatments and evaluations are necessary to determine the long-term impact on the Canada thistle population.

INTRODUCTION

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

[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.

accomplished by mowing or applying herbicide(s) two times each year (spring and fall) for multiple years, followed by an ongoing maintenance program.[2]

In the fall of 2010, a study 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. This study used a combination of mowing and herbicides. Mowing or chemical mowing to limit the above ground growth were used as the spring control method in all treatments, while the fall control method consisted of either mowing or an application of herbicides. The herbicides used as fall control measures were Milestone VM alone, combinations of Milestone VM + Overdrive, or Perspective + Overdrive. This is a report of the preliminary results of a long-term study. This study was conducted to determine if applying control measures twice per year over multiple years is an effective strategy for controlling Canada thistle in a turf environment.

MATERIALS AND METHODS

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

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

Canada thistle stem counts were obtained by counting the number of stems in an 11 sq ft. subplot at a randomly chosen but fixed location within each plot. Percent cover by Canada thistle and grass species was estimated by visual observation. The first treatments were performed and initial Canada thistle stem counts taken on September 15, 2010 and September 24, 2010 for the Mountville and Indiana sites, respectively. Sites were evaluated for number of Canada thistle stems and ongoing treatments were applied on May 26, 2011, 253 days after initial treatment (DAIT) and September 22, 2011 (373 DAIT) for the Mountville site and May 24, 2011 (242 DAIT) and September 21, 2011 (363 DAIT) for the Indiana location. During the last visit to each site the total vegetative cover within each plot was also recorded. Quantitative data were subjected to analysis of variance. When treatment effect F tests were significant ($p \leq 0.05$), means were compared using the Tukey HSD test.

[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

RESULTS AND DISCUSSION

Initial Canada thistle cover averaged 5.5% at the Mountville location and 44% at the Indiana site. At the Mountville site at 253 DAIT, treatments that included a fall herbicide application had significantly lower numbers of Canada thistle stems in the subplots compared to fall mowing. Actual stem counts were ≤4 stems for fall herbicide (98 to 100% reduction) versus 25 stems for fall mowing (24% reduction). At the Indiana location as well, treatments with a fall herbicide application significantly outperformed those that utilized fall mowing at reducing Canada thistle stem counts at both 242 and 363 DAIT. Stem counts at 242 DAIT were ≤1 stem for fall herbicide (98 to 100% reduction) versus 41 stems for fall mowing (32% reduction) and ≤9 stems for fall herbicide (88 to 100% reduction) versus 55 stems for fall mowing (8% reduction) at 363 DAIT (Tables 1 and 2). All treatments, including mowing two times per year, reduced the number of Canada thistle stems per plot at both sites approximately 1 year after the initial treatment (373 DAIT for the Mountville site and 363 DAIT for Indiana).

CONCLUSIONS

Results one year after the initial treatment indicate that all treatments reduced the number of Canada thistle stems. By 363 DAIT, treatments made at the Indiana site that included a fall herbicide application rather than fall mowing, appear to be more effective at reducing thistle populations than mowing alone. A competitive grass cover may have contributed to the effectiveness of the treatments at both sites. The effectiveness of the control measures on sites where turf is not well established or where broadleaf vegetation is the primary groundcover should be considered as a topic for additional study.

MANAGEMENT IMPLICATIONS

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

Table 1. Canada thistle stem counts and total vegetation cover ratings for the SR 30 study site near Mountville PA. Initial treatments and evaluations were conducted on September 15, 2010 and subsequent visits occurred on May 26 and September 22, 2011, 253 and 373 days after initial treatment (DAIT). Numbers represent the mean of three replications. Column means followed by the same letter are not significantly different at p≤0.05. Percent total cover ratings were not tested for significant differences between treatments.

Treatment	Initial Stem Count September	Stem Count May 2011 253 DAIT	Stem Count September 2011 373 DAIT	% Total Cover 2011 373 DAIT
Mow Spring and Fall	33 a	25 a	8 a	82
Mow Spring, Milestone Fall	33 a	2 b	0 a	85
Mow spring, Milestone + Overdrive Fall	43 a	4 b	1 a	82
Mow Spring, Perspective + Overdrive Fall	38 a	0 b	0 a	87
Chemical Mow spring, Milestone + Overdrive Fall	62 a	0 b	0 a	72
Chemical Mow Spring, Perspective + Overdrive Fall	39 a	0 b	0 a	83

Table 2. Canada thistle stem counts and total vegetation cover ratings for the SR 30 study site near Indiana PA. Initial treatments and evaluations were conducted on September 24, 2010 and subsequent visits occurred on May 24 and September 21, 2011, 242 and 363 days after initial treatment (DAIT). Numbers represent the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$. Percent total cover ratings were not tested for significant differences between treatments.

Treatment	Initial Stem Count September 2010	Stem Count May 2011 242 DAIT	Stem Count September 2011 363 DAIT	% Total Cover September 2011 363 DAIT
Mow Spring and Fall	60 a	41 a	55 a	100
Mow Spring, Milestone Fall	58 a	1 b	5 b	100
Mow spring, Milestone + Overdrive Fall	59 a	0 b	1 b	70
Mow Spring, Perspective + Overdrive Fall	81 a	0 b	9 b	100
Chemical Mow spring, Milestone + Overdrive Fall	74 a	1 b	0 b	99
Chemical Mow Spring, Perspective + Overdrive Fall	45 a	0 b	1 b	100

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

<u>Plant common and scientific names:</u> 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*), 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 replicated trial was established to test the relative establishment of Formula N, a native seed mix containing WSG and several legumes, against Formula C, a standard mix of crownvetch and annual ryegrass. Planting dates for the study were February 13th, April 23rd, July 7th, and August 21st. Results from data collected in September 2011 indicate that WSG plots seeded in February yielded the largest number of Indiangrass (1.0), big bluestem (2.0), switchgrass (0.4), and little bluestem (0.9) plants per sq. ft., as well as the highest percent cover by WSG (25%). Formula N plots seeded in April produced the largest number of Virginia wildrye plants (1.3) per square foot and the second largest number of the four WSG species. Partridge pea and showy tick-trefoil, the legumes included in the Formula N mix, were evident in very low numbers in only two plots. For plots seeded to Formula C, the April seeding produced the highest percent cover (65%), followed by August (30%), July (4%), and February (3%). It appears that 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 PA 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 WSG are slow and sometimes difficult to get established.[2] The purpose of this study, started in 2009, is to evaluate the ability of native WSG species to establish at four seeding dates throughout the year compared to the traditional use of crownvetch. Results from the 3rd year after seeding follow.

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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.

Materials and Methods

This study 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), subjected to four planting windows: Nov to Feb, Mar to May, Jun to July, and Aug to Sep. Actual seeding within these timeframes 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 site, approximately .49 ac., was prepared by ripping and grading on October 16, 2008, and seeded with cereal rye on October 22, 2008 to provide vegetative cover. Along with the rye, 46-0-0 urea, and 39-0-0 sulfur coated urea were applied at a rate of 15 and 5.9 lbs per 1000 S.Y., respectively. At each of the timing intervals, together with the formula N and Formula C seed mixes, additional soil amendments were broadcast including 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.

On September 16, 2011, approximately 25 months after the last seeding, all plots were visually evaluated to estimate percent cover by crownvetch, percent total cover, and percent cover by WSG (only native seeded plots). The plots seeded with native mixes in February and April produced enough WSG plants present to make visual estimation of plant numbers impractical. Fixed subplot sampling was used to count the WSG plants on 2% of the area within these plots. Subplots were identified by establishing a 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 plot was determined 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. For the native seed mixes, the plots seeded in February produced the highest percent cover by WSG (25%) followed by plots with an April seeding date (20%). Plots seeded in July and August both showed only 1% cover by WSG. Stem counts for individual WSG species showed that plots with February timing yielded the largest number of Indiangrass, big bluestem, switchgrass, and little bluestem plants, 1.0, 2.0, 0.4, and 0.9 plants per sq. ft. respectively. Plots seeded in April produced the highest number of Virginia wildrye plants (1.3 plants per sq. ft.) and the second highest number of stems among the WSG species. WSG plant counts were not calculated for plots seeded in July or August because there were not enough WSG plants present (1% cover) to warrant sampling.

Formula N plots seeded in July were rated as having the highest total cover (87%), a number that was boosted by an 80% cover by crownvetch in one of the three plots. It seems plausible that crownvetch invaded this plot from an adjoining area. For plots seeded to crownvetch (Table 4), the April seeding produced the highest percent cover at 65% crownvetch

(65%), followed by August at 30%, July at 4% and February at 3%. A thorough description of the site and first full year results after seeding can be found at Johnson et al.[3,4]

Conclusions

From the data gathered at three years into the study and two full growing seasons, late winter through early spring appears to be the most favorable time to establish WSG cover. This corresponds with germination and growth expectations outlined by the Ernst Seeds company (www.ernstseeds.com) in that spring soil moisture conditions and soil temperatures of 55°F or greater provide for the greatest development. July and August appear to be poor time to seed sites with WSG mixes. Ernst also notes 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 seedling due to the heavy investment by the seedling in root development over shoot growth. This study has entered the window where greater visible presence of seedlings should be recorded. Crownvetch established best when seeded in April and August. It seems reasonable that planting in April places the seed in the soil at the time when fluctuating temperatures and adequate soil moisture are present. Late August often signals the start of cooler night temperatures of the fall season. Crownvetch remains a more rapid, expansive, and competitive ground cover on poor sites compared to WSG seeding. This is apparent in the coverage after seeding and in the competitive creep of crownvetch into WSG seeded sites. Reliance on WSG as a revegetation option requires a commitment to native mixes and a willingness to allow time and provide 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. Better, more consistent establishment rates for WSG will have to be documented before the mix could be considered for operational use.

[3] Johnson et al. 2010. Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass. Roadside Vegetation Management Research Report – Twenty-fourth Year Report. pp. 57-60.
[4] Johnson et al. 2011. Seasonal Timing Effects on Warm-Season Grass Establishment Relative to Crownvetch and Annual Ryegrass – Year Two. Roadside Vegetation Management Research Report – Twenty-fifth Year Report. pp. 59-63.

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

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

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

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

Table 3. Cover ratings for plots seeded to Formula N, warm season grasses (WSG). Seedings occurred February 13, April 23, July 7, and August 21, 2009. Data was recorded at approximately 25 month after the last seeding. Plots seeded in February and April had enough WSG plants present to warrant sampling of subplots to establish an estimate of plants per square foot. Crownvetch cover reported is based on volunteers emerging in the treatment area not on a planned seeding activity. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at p≤0.05 .

Treatment	Timing	% Cover by Crownvetch	% Total Cover	% Cover by WSG	Stems per Square Foot				
					Indiangrass	Big Bluestem	Switchgrass	Virginia Wildrye	Little Bluestem
Native	Feb	1	68	25 a	1.0 a	2.0 a	.4	0.6	0.9 a
Native	Apr	8	72	20 ab	0.3 ab	1.4 ab	.2	1.3	0.3 b
Native	Jul	28	87	1 b	0 b	0 b	0	0	0 b
Native	Aug	2	73	1 b	0 b	0 b	0	0	0 b

Within each column, numbers followed by different letters are significantly different at the .05 level

Table 4. Cover ratings for plots seeded to Formula C, crownvetch. Seedings occurred February 13, April 23, July 7, and August 21, 2009. Data was recorded approximately 25 months after the last seeding. Each value is the mean of three replications. Differences between means were considered statistically significant at p≤0.05. N.S. = not significant.

Treatment	Timing	% Cover by Crownvetch	% Total Cover
Crownvetch	Feb	3	48
Crownvetch	Apr	65	88
Crownvetch	Jul	4	73
Crownvetch	Aug	30	63
		N.S.	N.S.

EVALUATION OF NATIVE SEED MIXES FOR ROADSIDE APPLICATION

Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), annual sowthistle (*Sonchus oleraceus*), autumn bentgrass (*Agrostis perennans*), barnyardgrass (*Echinochloa crus-galli*), big bluestem (*Andropogon gerardii*), birdsfoot trefoil (*Lotus corniculatus*), buckhorn plantain (*Plantago lanceolata*), Canada wildrye (*Elymus canadensis*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), devil's beggartick (*Bidens frondosa*), giant foxtail (*Setaria faberi*), green foxtail (*Setaria viridis*), hard fescue (*Festuca brevipila*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), oats (*Avena sativa*), partridge pea (*Chamaecrista fasciculata*), sheep fescue (*Festuca ovina*), switchgrass (*Panicum virgatum*), tall fescue (*Festuca arundinacea*), wild senna (*Senna hebecarpa*).

ABSTRACT

In 2000, the PA Department of Conservation and Natural Resources classified crownvetch as a "situational invasive" in the publication *Invasive Plants in Pennsylvania*. Since this listing several demonstration plots have been established to examine the germination and establishment of alternative seed mixes in the roadside environment. Warm-season grasses have many attributes that make them suited for this application. They are adapted to the heat, drought, variable pH levels, and low fertility often encountered on these sites. Unfortunately, warm-season grasses commonly take several years to establish. To assure a stable groundcover while the warm-season grasses are developing, a site tolerant intermediate grass species in combination with an immediate short-term groundcover crop (e.g., oats) would assure site and soil stabilization. To this end, sheep fescue, a perennial, cool-season, and bunch-type grass, is a good candidate as the intermediate cover. Sheep fescue is adapted to drought, pH levels from 5.5 to 7.5, and medium fertility. Two demonstration sites were seeded with sheep fescue at two rates at each site (i.e.,10 and 20 lbs/acre) along with oats as the immediate cover crop, and big bluestem, little bluestem, Indiangrass, switchgrass, wild senna, and partridge pea as the long-term groundcover component. One demonstration site was hydroseeded and the other was broadcast by hand and covered with an erosion blanket. As a long-term project, the first season results are preliminary in terms of the warm season grass and sheep fescue establishment and varied based on site; however, the sheep fescue appeared to be slowly establishing with total vegetative cover at 10 to 60% depending on site and sheep fescue rate. Observations in 2012 will provide more insight on the potential for this species and use rates in combination with warm-season grass mixes.

INTRODUCTION

Road construction projects often lead to significant site disturbance and degraded soil quality. While it is imperative to establish groundcovers on the roadside, many plant species are not adapted to the poor soil conditions and harsh environment. Crownvetch has been a standard groundcover used in many roadside plantings, especially in the steep, droughty, and low nutrient sites. In recent years, crownvetch has come under scrutiny and been labeled as a 'situational invasive' by Pennsylvania's Department of Conservation and Natural Resources.[1] Our search for alternative groundcover options has led to warm-season grass mixes. A few species under consideration include big bluestem, little bluestem, Indiangrass, and switchgrass.[2] These plants are adapted to a range of pH levels from 4.5 to 7.8, moderate to high drought tolerance, low to moderate salt tolerance, and full sun.[3] The plants are deep rooted and tall, growing up to 7 feet for some species, under optimum growing conditions. These grasses are meant for areas beyond the typical mow-line, perhaps 30 feet from the road edge or within large interchange areas where sight distance is not sacrificed and mowing will be minimal or not occur. Although they take several years to establish, these warm-season native grasses are competitive once established and provide visual interest and wildlife habitat. The slow development and establishment of native warm-season grasses requires that an immediate and intermediate groundcover stand be planned into the seeding mix deployed along the roadside to protect and anchor the soil. Spring oats acts as the immediate groundcover component. In exploring suitable intermediate groundcover components, previous plots have included Canada wildrye and autumn bentgrass with little success.[4] In this evaluation, two sites were seeded with two rates of sheep fescue along with spring oats and a combination of warm-season grasses to determine its success in establishment. Additionally, two herbaceous perennials, partridge pea and wild senna, were added to the mix to evaluate the germination and growth of these species in a roadside environment.

MATERIALS AND METHODS

The seed mixes were applied at two locations, along SR 422 near Indiana, PA and I-99 near Port Matilda, PA. The Indiana location was a fill site for a recent construction project. The plots were composed of a gravelly substrate that was level across much of the area, but included a steep slope of about 20 feet along the back edge of the site. The parcel was divided into three individual plots. Plot sizes for the Formula N (native warm season grass mix with sheep fescue) designated FN10, FN20, and a control plot consisting of Formula L, a standard cool season grass mix of fine fescue) were 8,242; 9,300; and 10,800 sq ft, respectively. The FN10 and FN20 plots were broadcast, hand-seeded at 64 and 74 lb pure live seed (PLS)/ac on October 21, 2010 (Tables 1, 2). Immediately after seeding, a 3000 gallon capacity T330 Finn Hydroseeder was used to apply mulch and soil supplements. Soil amendments were incorporated in the liquid slurry at a rate of 2000 lbs high calcium pulverized lime, 1000 lbs 10-20-20 and 50 lbs 38-0-0 fertilizers, and 1000 lbs Second Nature recycled paper mulch[5] per 3000 gallons of water. Approximately 1,500 gallons was applied to both Formula N plots totaling 17,542 sq ft. The Formula L seed mix was later added to the slurry and hydro-seeded at 116 lb/ac onto the third

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[1] Invasive Plants in Pennsylvania. 2006. PA DCNR. 25 Jan. 2012 <http://www.dcnr.state.pa.us/forestry/InvasivePlantBrochure.pdf>

[2] Johnson et al. 2009. Native Seed Mix Establishment Implementation. Roadside Vegetation Management Research – 2009 Report. pp. 50-53.

[3] Ernst Conservation Seeds. 2012. Ernst Conservation Seeds. 25 Jan. 2012 <http://www.ernstseed.com>

[4] Johnson et al. 2011. Native Seed Mix Establishment-Year Three. Roadside Vegetation Management Research – 2011 Report. pp.54-58.

[5] Second Nature Paper Fiber Mulch (Central Fiber Corporation, Canton, OH)

plot (Table 3). Percent cover by desirable vegetation was evaluated on May 24 and September 19, 2011, 215 and 333 days after treatment, DAT.

The Port Matilda seeding occurred on a steep slope (2:1). The area was previously seeded to crownvetch during construction of the I-99 corridor several years prior, but was nearly devoid of vegetation and gullied in a few spots by erosion at the time of treatment. On June 21, 2011 the site was divided into two equally sized plots 20 by 70 ft (1400 sq ft). Amendments and seed were broadcast by hand across the plots. Both received 100 lb pelletized lime, 10.9 lb 0-46-0, 3.2 lb 0-0-62, 3.5 lb 20-10-10, and 0.8 lb 39-0-0 per 1000 sq ft. This equates to 100 lb limestone, 5 lb P_2O_5, 2 lb K_2O, 0.7 lb N, and 0.3 lb N slow release per 1000 sq ft recommended from soil test results taken June 6, 2011. Following the application of soil amendments the plots were seeded by hand broadcasting FN10 at 64 lb PLS/ac or FN20 at 74 lb PLS /ac. The plots were immediately covered with a straw-based, erosion control blanket.[6] An evaluation of percent total vegetative cover and percent cover by desirable grasses was made on September 16, 2011, 87 DAT.

RESULTS AND DISCUSSION

Sheep fescue germinated and grew at the Indiana, PA site. Unexpectedly, the establishment of sheep fescue was greater within the FN10 versus the FN20 plot when evaluated 215 DAT, despite having half the amount of the species in the mix. The FN10 plot was rated at 10 percent cover by sheep fescue, while the FN20 plot rating was only 3 percent. The difference could be attributed to the variability in soil quality from one plot to the next. The plot seeded to FN20 had greater compaction and more stone particulates than the FN10 plot. No other desirable species were noted within the plots. Fine fescue accounted for 10 percent cover within the Formula L plot by the same date.

At 333 DAT, the FN10 plot showed 10 percent total vegetative cover and a reduction to 5 percent cover by desirable grasses. Half of the desirable cover, 2.5 percent, consisted of sheep fescue. The remaining desirable cover was comprised of big bluestem, Indiangrass, and switchgrass. The FN20 plot produced substantially more total vegetative cover at 65 percent. The cover by desirable grass species was similar to the FN10 plot at 5 percent. Sheep fescue accounted for 2.5 percent of the cover and the remainder was again big bluestem, Indiangrass, and switchgrass. A few partridge pea plants were found in both plots. Other prevalent species found within both the FN10 and FN20 plots were devil's beggartick, annual sow thistle, birdsfoot trefoil, barnyardgrass, and giant foxtail. The Formula L plot produced 90 percent total vegetative cover, mostly by birdsfoot trefoil. Fine fescue accounted for only 2 percent cover. Other common species included barnyardgrass, green foxtail, tall fescue, and buckhorn plantain.

The Port Matilda site was evaluated 87 DAT. Total vegetative cover was 60 and 15 percent in the FN10 and FN20 plots, respectively. Crownvetch that developed from existing crowns or seed accounted for most of the cover present by this date. Less than 1 percent of the cover was attributed to desirable grasses. These grasses included oats, big bluestem, and Indiangrass. Only four partridge pea plants and single wild senna were found within the FN10 plot, while none were observed in the FN20 plot.

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[6] ECS-1 (East Coast Erosion Control Blanket, LLC, Bernville, PA)

CONCLUSIONS

The establishment of the immediate and intermediate covers, oats and sheep fescue, was variable for both seed mixes and between the two sites. None of the plots provided excellent cover by desirable species within the first season of development. The results demonstrate that sheep fescue is developing on the sites along with the warm season native grasses; however, one growing season on such challenging sites will not provide conclusive results and the sites will continue to be monitored over the next several years. We anticipate the upcoming growing season will further define the suitability of sheep fescue as an intermediate groundcover.

MANAGEMENT IMPLICATIONS

The formulas offered within the Publication 408, section 804 'Seed and Soil Supplements', should be followed until a suitable mix is identified.[7] Warm-season grasses used within the FN10 and FN20 mix are possible candidates for seeding on some sites. However, it may take several years for adequate establishment to occur until a proven, intermediate cover is identified.

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[7] PennDOT. Pub 408, Section 804 – Seed and Soil Supplements.

Table 1: Formula FN10 seed mix for the Indiana and Port Matilda establishment projects. Components are reported as lb/ac pure live seed (PLS). PLS = % germination x % purity/100.

scientific name	common name	seeding rate	
		lb/ac	lb/1000 S.Y.
Avena sativa	spring oats	30	6.0
Festuca ovina	sheep fescue	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
Senna hebecarpa	wild senna	2	0.4
Chamaecrista fasciculata	partridge pea	2	0.4
Total		64	12.8

Table 2: Formula FN20 seed mix for the Indiana and Port Matilda establishment projects. Components are reported as lb/ac pure live seed (PLS). PLS = % germination x % purity/100.

scientific name	common name	seeding rate	
		lb/ac	lb/1000 S.Y.
Avena sativa	spring oats	30	6.0
Festuca ovina	sheep fescue	20	4.0
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
Senna hebecarpa	wild senna	2	0.4
Chamaecrista fasciculata	partridge pea	2	0.4
Total		74	14.8

Table 3: Formula L seed mix per PennDOT Pub. 408, Section 804-Seeding and Soil Supplements.

scientific name	common name	seeding rate	
		lb/ac	lb/1000 S.Y.
Festuca longifolia	hard fescue mix	63	13.0
Festuca rubra	creeping red fescue	41	8.5
Lolium multiflorum	annual ryegrass	12	2.5
Total		116	24

NATIVE SEED MIX ESTABLISHMENT IMPLEMENTATION – YEAR FOUR

Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), aster (*Aster* spp.), autumn bentgrass (*Agrostis perennans*), big bluestem (*Andropogon gerardii*), black-eyed susan (*Rudbeckia hirta*), black locust (*Robinia pseudoacacia*), brambles (*Rubus* spp.), Canada wildrye (*Elymus canadensis*), coltsfoot (*Tussilago farfara*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), fine fescue (*Festuca rubra*), giant foxtail (*Setaria faberi*), hard fescue (*Festuca brevipila*), Indiangrass (*Sorghastrum nutans*), Japanese knotweed (*Fallopia japonica*), little bluestem (*Schizachyrium scoparius*), multiflora rose (*Rosa multiflora*), ox-eye sunflower (*Heliopsis helianthoides*), partridge pea (*Chamaecrista fasciculata*), spring oats (*Avena sativa*), staghorn sumac (*Rhus typhina*), switchgrass (*Panicum virgatum*)

ABSTRACT

Formula N is a native warm-season grass (WSG) mix designed as an alternative ground cover for use in difficult disturbed sites. Formula N was deployed by broadcast and hydroseeding at two sites on steep, low fertility, erosion prone, and coarse soil textured sites in 2008. The observations reported here recorded in the fall of 2011 represent the fourth year after seeding and appear to show a plateau and decline in the number of WSG plants present compared to observations made in the summer of 2010. The 2010 observations representing the second year of establishment reported that the plants established were setting seed. In 2011, big bluestem, little bluestem, Indiangrass, and switchgrass were also present at both sites and producing seed heads; however, the overall population did not appear to be expanding. This may be in part due to the fact the new seedling may be developing their root system prior to top growth emerging; however, the percentage of plants per square foot appears to have dropped from 0.4 to 1 plant per square foot to 0.1 or fewer plants per square foot where plant densities were estimated. The intermediate components of the mix, Canada wildrye and autumn bentgrass have not provided satisfactory cover over the four years after seeding. In the present formulation not all components of Formula N are providing satisfactory results. The continued seed development among the big and little bluestem, Indiangrass, and switchgrass will continue to be monitored to follow whether plant density continues to diminish or the new seedlings fill out and expand the coverage; however, other native species and mixes should be considered for evaluation.

INTRODUCTION

PennDOT has several seed formulas available to use when revegetating sites impacted by disturbance or construction. For steep, low fertility, dry and coarse soil textured sites, Formula C, a blend of crownvetch and annual ryegrass has been the seed mix of choice. However, with the increased awareness of invasive plants and the observed potential invasiveness of crownvetch there has been a greater incentive to examine alternative species mixes for difficult sites.[1] In considering alternative mixes Formula N (Table 1) was designed and in 2008 it was deployed

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[1] PA Department of Conservation and Natural Resources, Invasive Plants in Pennsylvania, April 2006. <http://www.dcnr.state.pa.us/forestry/InvasivePlantBrochure.pdf>

through two application methods, hydroseeding and broadcasting, to explore the versatility of the Formula N mix. Observations on the third year after establishment and fourth year of the project are reported below.

MATERIALS AND METHODS

This demonstration was initiated in 2008 at two locations, along I-80W in Montour County and at a stockpile along SR56 near Homer City, PA. Both sites were steeply graded slopes with coarse textured, low fertility, and erosion-prone soil. In Montour County, half of the site was broadcast and the other half hydroseeded with Formula N (Table 1) on April 29, 2008. The Homer City site also included broadcast and hydroseeded plots of Formula N and two additional but separate plots consisting of Formula C (i.e., 19 lb/ac crownvetch and 24 lb/ac annual ryegrass) and Formula L (i.e., 63 lb/ac hard fescue, 41 lb/ac creeping red fescue, and 12 lb/ac annual ryegrass) hydroseeded on April 30, 2008. Amendments were applied according to PennDOT Pub. 408, section 804 specifications. Hydroseeding was performed as a one-step process, in which seed, mulch, and soil amendments were mixed and applied together as a slurry. Floc-Lock tackifier (Lesco) was added to the hydroseed mixture at a rate of 3 lb/acre. Broadcast plots included seed and amendments but were not mulched.

Documentation of the deployment and observations on seed establishment at the two sites in Homer City and Montour Co. has been reported in previous annual reports. [2,3,4] The Homer City and Montour Co. sites were evaluated for establishment success on September 19 and December 20, 2011, respectively with plant density on each site visually estimated.

RESULTS AND DISCUSSION

In its third year following establishment, the Montour County site showed a decline in desirable plant numbers compared to the previous years. Within the hydroseeded plots only 35 percent of the slope was covered in vegetation. Approximately 98 percent of the vegetative cover was hard fescue present at the time of the initial seeding. The WSGs sparsely covered 1 percent of the area. A majority of the established WSGs was found along the upper portion of the slope where plant densities of 0.03 plants per sq. ft. were estimated. Few native grasses were found on the lower half of the slope.

The broadcast seeded area also showed a 35 percent cover by vegetation. Hard fescue tufts accounted for 95 percent of this vegetation. Warm-season grass species provided only 2.5 percent of the cover throughout the plot. Again, most of the desirable native grasses were located along the top half of the slope with an estimated 0.1 plants per sq. ft. while the lower portion carried few plants. There were fewer plants observed in 2011 compared to 2010 where a maximum of 1 plant per sq. ft. along the upper part of the slope were reported.[4]

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[2] Johnson et al. 2009. Native Seed Mix Establishment Implementation. Roadside Vegetation Management Research Report. pp. 50-53.
[3] Johnson et al. 2010. Native Seed Mix Establishment Implementation – Year Two. Roadside Vegetation Management Research Report. pp. 43-45.
[4] Johnson et al. 2011. Native Seed Mix Establishment Implementation – Year Three. Roadside Vegetation Management Research – 2011 Report. pp. 54-58.

The native grass species observed at this location included: Indiangrass, little bluestem, Canada wildrye, big bluestem, and switchgrass. The lateness of the 2011 rating made it impossible to discern whether partridge pea or black-eyed susan were present within the entire study area and may have contributed to the diminishing cover ratings given to the WSGs since senescence had already occurred.

At the Homer City site there were more native warm-season grass plants observed than at the Montour Co. site. Total vegetative cover varied from 75 to 50 percent for hydroseeded and broadcast plots, respectively. Common weed species encountered were crownvetch, black locust, staghorn sumac, multiflora rose, giant foxtail, aster, brambles, coltsfoot, and Japanese knotweed. Both the hydroseeded and broadcast sections offered similar cover by WSGs and accounted for 5 percent of the overall vegetative cover. The species present included: Indiangrass, big bluestem, switchgrass, little bluestem, and Canada wildrye. As with the Montour Co. site, most of the desirable grasses were established along the upper one-half of the plots with an average density of 0.1 plants per sq. ft. This plant density represents a decline from the density reported in 2010 at 0.4 to 1 plant per sq. ft. A small population of partridge pea plants was observed within both the hydroseeded and broadcast plots.

The observed reduction in cover for the WSG species in 2011 were also observed for the Formula L fescue and ryegrass mixes and Formula C crownvetch mix at the Homer City site from the 2008 seeding. In 2010 the Formula L percent cover was reported at 5 to 10 percent; however, by 2011 the percent cover had dropped to a maximum of 2 percent cover by fine fescue and only 5 percent total vegetative cover. Similarly, the Formula C plot was visually estimated at 50 percent crownvetch cover compared nearly 100 percent cover in 2010.[4] This across the board reduction in cover by all formula mixes suggests that environmental stresses may be playing a role which with 2011 being dry early and wet late spring into summer the cover may have been impacted. In addition, seed germination among the WSG species from the 2010 seed heads may have also been inhibited thus resulting in no visible signs of new seedlings in 2011.

CONCLUSIONS

Earlier reports described plant numbers at these sites as encouraging, but the 2011 rating demonstrated a steady to declining population of WSG plants suggesting that the WSGs are establishing slowly at both locations using either seeding method. At the Montour site this trend, in part, could be due to the lateness of the evaluation made in late December when many plants had already senesced. In addition, an obvious decline among all seeded treatments at Homer City suggests the highly variable environment experienced in central Pennsylvania in recent years may be having a detrimental effect on the establishment and continued ground cover spread. The 2011 observations represent the third establishment year for the Formula N mix. Past WSG studies have demonstrated the slowness of establishment of these species with five years being a common time limit for the success of study. Where previous trials have shown promise, the sites were typically on better quality soils capable of supporting other PennDOT Formulas.[5] The slow and sporadic progression of establishment may be an incentive to consider

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[5] Gover et al. 2003. 2002 Roadside Vegetation Management Conference (RVMC) Field Day Review – 'Roadsides for Wildlife' Native Species Planting Demonstration. Roadside Vegetation Management Research Report Seventeenth Year Report. pp 44-45.

other mixes or to consider other methods of application, such as multiple seedings over several years to boost success or alternative intermediate nurse crops or improved cultivars of WSG species. The long-term success of WSG species at both sites will continue to be monitored to determine what time period is needed for these areas to become established.

MANAGEMENT IMPLICATIONS

Presently there are no reasonable substitutes for the PennDOT Formulas currently available. Formulas D and L should be utilized where grasses are the desired groundcover and soil conditions will likely support these turf species. Formula C is still an option for sites with little and/or poor quality soils that require a plant species that will branch and spread by its above ground parts.

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

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

SLOPEMASTER SEED MIX DEMONSTRATION

Plant common and scientific names: chewings fescue (*Festuca rubra*), foxtail millet (*Setaria italica*), hard fescue (*Festuca brevipila*), perennial ryegrass (*Lolium perenne*), sericea lespedeza (*Lespedeza cuneata*), tall fescue (*Festuca arundinacea*), white clover (*Trifolium repens*) yellow sweet clover (*Melilotus officinalis*).

ABSTRACT

Revegetating disturbed sites on the roadside is important to roadside vegetation managers. A seed mix must establish rapidly and thrive under the broad environmental conditions encountered on the right-of-way. Slopemaster, a 'Durana' white clover based seed mix is designed for rapid establishment, durability, and low maintenance (Pennington Seed Inc., Madison, GA). Two forms of Slopemaster were evaluated; one that contains fine fescue and another that contains tall fescue as the primary component. A demonstration area was established where both mixes were seeded on a previously disturbed construction site. Both seed mixes established on the site with 50% and 85% cover for the fine fescue and tall fescue mixes, respectively at 109 days after seeding (DAS). At 767 DAS, the cover from species included in the seed mixes appeared to have decreased with time, to 49% for the fine fescue plot and 48% for the tall fescue plot. The percent clover coverage varied with 10% cover in the fine fescue plot and 20% cover in the tall fescue plot at 767 DAS. It should be recognized that seasonal variation in vigor of the clover and fescue cover may be a factor in ratings conducted over a one year period. In addition, this demonstration comparison represents a preliminary experiment and was not replicated on site to allow for confirming statistical differences.

INTRODUCTION

Slopemaster is a white clover based seed mix (Pennington Seed Inc., Madison, GA) designed for erosion control, ease of establishment, and low maintenance. The unique component of Slopemaster is 'Durana' white clover, a perennial, medium leafed, intermediate type white clover, promoted for its ability to produce 97 stolons per square foot, fix 150 lbs. of nitrogen per acre per year, and form a permanent ground cover. Two mixes, each containing 10% 'Durana' clover are offered in the marketplace with one incorporating 60% 'Predator' hard fescue, 20% '7 Seas' chewings fescue, and 10% 'T-3' perennial ryegrass and another consisting of 70% 'Greystone' tall fescue, 10% 'T-3' perennial ryegrass, 5% sericea lespedeza and 5% foxtail millet. These mixes can be planted using a seed drill, broadcast equipment, or hydroseeding unit. A preliminary demonstration was designed to compare the success of establishment and development of these two seed mixes on a roadside site following disturbance by construction.

MATERIALS AND METHODS

The trial was established on a gently sloping, fill site on the shoulder of I-99 northbound west of State College, PA. The two seed mixes were broadcast by hand over an area of 2500 sq. ft. each on April 22, 2009. The seeding rates were approximately 90 and 125 lb/ac for the fine fescue and the tall fescue mixes, respectively. Soil amendments and straw mulch were added according to PennDOT Pub. 408 specifications, Sections 804 and 805. The plots were evaluated for vegetative cover on August 9, 2009 (109 days after seeding, DAS), May 26, 2010 (399 DAS), and September 16, 2011 (767 DAS).

RESULTS AND DISCUSSION

At 109 DAS, the fine fescue mix and the tall fescue mix produced 50% and 85% cover (Table 1), respectively, with 'Durana' white clover establishing at a greater rate on the area seeded to fine fescue.[1] At 399 DAS, percent cover by species included in the seed mixes rose to 65% for the fine fescue mix and dropped to 72% for the tall fescue mix, while percent cover by clover was 20% for the fine fescue mix compared to 2% for the tall fescue plot. At the last rating, 767 DAS, the percent cover by species included in the seed mix was estimated at 49% for the fine fescue mix and 48% for the tall fescue mix. At this rating, percent cover by white clover decreased to 10% in the fine fescue plot but increased to 20% in the plot seeded to the tall fescue mix. Other species present at 767 DAS, predominantly yellow sweet clover, represent 49% and 32% of the vegetative cover in the fine fescue and tall fescue plots respectively.

CONCLUSIONS

Both mixes appeared to establish quickly with the cover by species included in the seed mixes holding relatively stable over time in the fine fescue plots, ranging from 50% to 49%, but decreasing over time in the tall fescue plot, 85% to 48%. To date, percent cover by clover has been inconsistent, decreasing over time in the plot seeded to fine fescue and increasing over time in the tall fescue plot. The data may have been influenced by seasonal differences in the vigor of the grass and clover components of the mixes, which might account for some of the variation. Future evaluations are anticipated for both spring and fall to identify any variations in desirable plant composition that might occur during the season.

The use of these mixes in a roadside setting has advantages and disadvantages. A significant advantage is the clover plant's ability to fix atmospheric nitrogen and make this essential element available to other plants. One area of concern is with sericea lespedeza, also referred to as Chinese lespedeza, which has been noted for its potential for being highly invasive in some areas, including Pennsylvania.[2,3] Sericea lespedeza has not demonstrated utility in these seed mixes and should not be included in future evaluations.

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1 Johnson et al. 2010. Slopemaster White Clover Seed Mix Demonstration. Roadside Vegetation Management Research - 2010 Report. pp. 66-67.

2 USDA/NRCS, "Plant Fact Sheet: Chinese Lespedeza, *Lespedeza cuneata*," 24 May 2006. 29 May 2012. <http://plants.usda.gov>.

3 The Bugwood Network et al., "Mid-Atlantic Exotic Pest Plant Council Plant List," 24 Jan. 2005. 29 May 2012. <http://www.invasive.org/maweeds.cfm>.

MANAGEMENT IMPLICATIONS

PennDOT currently utilizes mixes that contain primarily tall fescue (Formula D) and fine fescue (Formula L). If either Slopemaster mix has a significant value to the vegetation management program, it would be in the introduction of 'Durana' white clover as a low growing, perennial groundcover component. Results to date show inconsistent establishment of the clover. Continued evaluation of these demonstration plots may help to clarify the ability of the 'Durana' clover to establish itself on this type of site and help identify the desirability of clover as an ingredient of a roadside seed mix.

Table 1. Summary of percent cover for the major components of the fine fescue and tall fescue Slopemaster seed mixes. The site was seeded on April 22, 2009.

	8/6/2009 (109 DAS)		5/26/2010 (399 DAS)		9/16/2011 (767 DAS)	
	Fine Fescue	Tall Fescue	Fine Fescue	Tall Fescue	Fine Fescue	Tall Fescue
White Clover	NA	NA	20	2	10	20
Fine Fescue	NA	NA	45	---	39	---
Tall Fescue	NA	NA	---	70	---	28
Total Species From Seed Mix	50	85	65	72	49	48
Other Species present	NA	NA	NA	NA	49	32
Total Cover	NA	NA	NA	NA	98	80

NA indicates data not available

INDAZIFLAM AS A PREEMERGENCE COMPONENT IN A BARE GROUND WEED CONTROL PROGRAM

Herbicide trade and common chemical names: Karmex (*diuron*), Oust XP (*sulfometuron*), Roundup Pro Max (*glyphosate*), Specticle and Esplanade (*indaziflam*).
Plant common and scientific names: barnyardgrass (*Echinochloa crus-galli*), giant foxtail (*Setaria faberi*), prostrate knotweed (*Polygonum aviculare*), wild carrot (*Daucus carota*).

ABSTRACT

Recent label changes require additional personal protective equipment for loading and mixing personnel when using Karmex, a preemergence herbicide commonly used in tank mixes for bare ground weed control. As an alternative, *indaziflam* was tested alone at 5 oz/ac, and at two rates (3.5 and 5 oz/ac) in combination with Oust XP at 3 oz/ac. Specticle, a product with a label for landscape use and providing an equivalent amount of active ingredient when applied at the same use rate was substituted for the right-of-way labeled product Esplanade in this experiment due to limited availability of Esplanade. Other treatments in the experiment included the industry standard, Karmex at 128 oz/ac + Oust XP at 3oz/ac, *glyphosate* alone at 64 oz/ac, and an untreated check. The study sites were visually evaluated for percent control at approximately 30, 60, 90, 120 and 180 days after treatment, DAT. All tank mix treatments provided excellent and statistically similar control of 88 to 100 percent at the final evaluation. Based on this experiment, *indaziflam* may be an effective alternative to *diuron* as a premergence component to a bare ground weed control program.

INTRODUCTION

Maintaining bare ground under guiderails and around roadside structures is accomplished with a tank mix of herbicides. Typically, a postemergence weed control product is used, along with a broad-spectrum residual herbicide and a preemergence product. Considerations used to select herbicides include: cost, availability, safety, rotation of products having different modes of action, duration of control, and effectiveness on the weed species present at the site. Karmex (*diuron*) is a standard component of bare ground tank mixes and has undergone some label changes that require additional personal protective equipment, PPE (e.g a particulate filtering respirator), for personnel mixing and loading, rendering it less desirable to use. An experiment was conducted to evaluate the use of indaziflam as an effective replacement for *diuron* in bare ground weed control programs.

MATERIALS AND METHODS

A replicated experiment was initiated at two sites to compare the efficacy of *indaziflam* alone and at two rates in combination with Oust XP, relative to a Karmex plus Oust XP mixture, the industry standard. For this experiment, Specticle 20 WSP, a product labeled for landscape use was used in place of Esplanade 200SC. Both products contain the active ingredient (a.i.) *indaziflam* and when applied at the same rate of product per acre provide identical amounts of a.i. The experiment was conducted under the guiderail at two sites, one along Fox Hollow Road near State College, PA and the other along I-99 North near Port Matilda, PA. Six treatments were applied at each site and included a control treatment of *glyphosate* alone at 64 oz./ac; Specticle alone at 5 oz/ac; Specticle at 3.5 and 5 oz/ac plus Oust XP at 3 oz/ac; Karmex at 128 oz plus Oust XP at 3 oz/ac; and an untreated check. All test treatments included Roundup Original Max at 64 oz/ac and all treatments included Induce non-ionic surfactant at 0.25 v/v. At the Fox Hollow Road site, treatments were applied to 3 by 25 ft plots with four replications at 50 gal/ac on April 21, 2011 using a CO_2 powered backpack sprayer equipped with an ultra-low volume wand and single OC-08 spray tip. The first rainfall occurred nearly 23 hours after the application with a total precipitation of approximately .06 inches. At the I-99 site, plot size was 5 by 20 ft with three replications. All other details of the application at the I-99 site were identical to the Fox Hollow site with the exception of the spray tip, which was a Spraying Systems Boomjet XP25L. The first rainfall occurred nearly 26.5 hours following treatment with a total accumulation of approximately 0.31 inches.

The Fox Hollow site was visually evaluated for percent control on May 20 (29 days after treatment, DAT), June 20 (60 DAT), July 20 (90 DAT), August 24 (125 DAT), and October 17, 2011 (179 DAT) (Table 1). The I-99 location was visually rated for percent control on May 20 (29 DAT), June 25 (65 DAT), July 21 (91 DAT), August 23 (124 DAT), and October 15, 2011 (177 DAT) (Table 2). 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

At 29 DAT, all treatments containing Specticle and the industry standard, Karmex plus Oust XP provided 99 percent control at Fox Hollow and 100 percent control at the I-99 site. *Glyphosate* alone was evaluated at 99 and 93 percent control at Fox Hollow and I-99, respectively. Treatments containing Specticle and the Karmex plus Oust XP mix continued to provide similar control throughout the period of the study. By 179 DAT these treatments were rated at 88 to 98 percent control at the Fox Hollow Road location and 93 to 100% control, respectively, at the I-99 site at 177 DAT. In the final evaluation, 179 and 177 DAT, control by *glyphosate* was estimated at 55 and 42 percent for Fox Hollow Rd. and I-99, respectively. *Glyphosate* alone was not as effective as the best performing test treatments at either location. The primary weed species present during the final, October, rating were wild carrot and giant foxtail at the Fox Hollow site, while barnyardgrass, giant foxtail, and knotweed were among the weed species present at the I-99 site.

CONCLUSIONS

At nearly 5 months after treatment (MAT), Specticle continued to perform well at both sites, alone and in combination with Oust XP. All treatments containing Specticle provided control ratings similar to the industry standard, Karmex plus Oust XP over the entire growing season.

MANAGEMENT IMPLICATIONS

Indaziflam performed as well as the industry standard and received some of the highest control ratings throughout the season. It appears that *indaziflam* in the form of Esplanade, labeled for roadside vegetation management should be a reasonable substitute for Karmex in tank mixes for bare ground weed control based on this experiment applying Specticle at Esplanade equivalent rates. Additional testing using the Esplanade product would help to reinforce the utility of this product especially under unusual weather or environmental conditions and across a greater diversity of weed species. We do not recommend the single use of Esplanade or any other herbicide product in bare ground weed control treatments on the right-of-way. Season-long control of vegetation in these areas typically requires a combination of products with different modes-of-action. Due to the limited spectrum of species encountered at these sites, a single season of testing, and the results shown in Table 1 and 2, we suggest the use of the higher rate of Esplanade at 5 oz/ac unless further research confirms lesser rates will work with the Esplanade product.

Table 1. Percent control of vegetation at the Fox Hollow Road site near State College, PA. The trial was visually evaluated for percent control on May 20 (29 days after treatment, DAT), June 20 (60 DAT), July 20 (90 DAT), August 24 (125 DAT), and October 17 (179 DAT). Treatments were applied on April 21, 2011. All treatments included 64 oz/ac Roundup Pro Max and Induce non-ionic surfactant at 0.25 v/v. Each value is the mean of four replications.

Product		Percent Control				
	Rate oz/ac	29 DAT	60 DAT	90 DAT	125 DAT	179 DAT
Untreated	---	0 a	0 a	0 a	0 a	0 a
Glyphosate	64	99 b	96 b	70 b	53 b	55 b
Specticle	5	99 b	99 b	97 c	96 c	92 bc
Specticle Oust XP	3.5 3	99 b	99 b	99 c	99 c	98 c
Specticle Oust XP	5 3	99 b	99 b	99 c	99 c	98 c
Karmex Oust XP	128 3	99 b	99 b	95 c	94 c	88 bc

Within each column, numbers followed by different letters are significantly different at the 0.05 level

Table 2. Percent control of vegetation at the site along I-99 North near Port Matilda, PA. The trial was visually evaluated for percent control on May 20 (29 days after treatment, DAT), June 25 (65 DAT), July 21 (91 DAT), August 23 (124 DAT), and October 15 (177 DAT). Treatments were applied on April 21, 2011. All treatments included 64 oz/ac Roundup Pro Max and Induce non-ionic surfactant at 0.25 v/v. Each value is the mean of three replications.

Product		Percent Control				
	Rate oz/ac	29 DAT	65 DAT	91 DAT	124 DAT	177 DAT
Untreated	---	0 a	0 a	0 a	0 a	0 a
Glyphosate	64	93 b	75 b	72 b	65 b	42 b
Specticle	5	100 c	99 c	94 bc	96 c	96 c
Specticle Oust XP	3.5 3	100 c	98 bc	88 bc	93 c	93 c
Specticle Oust XP	5 3	100 c	100 c	100 c	99.c	100 c
Karmex Oust XP	128 3	100 c	99 c	99 c	99.c	97 c

Within each column, numbers followed by different letters are significantly different at the .05 level

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

Herbicide trade and common names: Authority (*sulfentrazone*), Escort (*metsulfuron*), Goal 2XL (*oxyfluorfen*), Karmex (*diuron*), MAT28 50SG (*aminocyclopyrachlor*), Matrix (*rimsulfuron*), Oust XP (*sulfometuron*), PennDOT Custom Blend or Streamline (*aminocyclopyrachlor* + *metsulfuron*), Prowl or Pendulum (*pendimethalin*), Roundup Original Max (*glyphosate*), Specticle or Esplanade (*indaziflam*), Surflan (*oryzalin*), Valor or Payload (*flumioxazin*).

Plant common and scientific names: barnyardgrass (*Echinochloa crus-galli*), giant foxtail (*Setaria faberi*), prostrate knotweed (*Polygonum aviculare*).

ABSTRACT

Providing season-long weed control in bareground settings is a challenge. The germination period for annual seeds often exceeds the length of residual activity of the preemergence herbicides in the soil. Bareground herbicide mixes are designed to provide broad spectrum residual control through a combination of preemergence and postemergence herbicides. Among preemergence herbicides the selection preference is for the use of a longer lasting active ingredient with postemergence activity to assure the broad spectrum control required in these areas of the right-of-way. MAT28 is a new synthetic auxin with broad spectrum residual activity and was applied at 6 oz/ac alone and in combination with several broad spectrum and limited spectrum preemergence herbicides to evaluate the effectiveness of each tank mix for total vegetation control. Other treatments included: *glyphosate* alone, *pendimethalin* plus Authority, PennDOT Custom Blend (i.e., mixture of MAT28 at 7.67 oz/ac and Escort XP at 0.33 oz/ac) or Streamline plus *indaziflam*, and the standard Karmex plus Oust XP. Prowl, Specticle, and Valor products are not labeled for non-crop right-of-way areas but contain the active ingredients *pendimethalin*, *indaziflam*, and *flumioxazin,* and were substituted due to availability of their non-crop labeled counterparts, Pendulum 3.3EC, Esplanade, and Payload, respectively. At 177 days after treatment, DAT, *glyphosate* at 64 oz/ac, MAT28 alone or combined with Matrix at 4 or Karmex at 64 oz/ac were similar in control to the untreated check and ranged from 23 to 52 percent. By this date, all other treatment combinations were effective and provided similar control values ranging from 87 to 100 percent. Based on this experiment and previous work, combinations of products containing the active ingredient (a.i.) in MAT28 (i.e., *aminocyclopyrachlor*) plus Surflan or *pendimethalin* appear to be effective herbicide combinations where short-term (i.e., days) staining of pavement or structures is not a concern.

INTRODUCTION

Bareground vegetation control treatments are expected to maintain areas weed-free for the entire growing season. Herbicide tank mixes are designed to provide broad spectrum residual control through a combination of postemergence and preemergence products, some of which have a longer residual and provide both preemergence and postemergence activity and are identified in this report as, broad-spectrum residual products (BSR). *Glyphosate* is commonly used as the postemergence herbicide. Products that are considered BSR herbicides include: Oust XP (*sulfometuron*), Krovar I (*bromacil*), and Arsenal (*imazapyr*). These products are applied at lower use rates to minimize the potential for off-site movement. MAT28 (*aminocyclopyrachlor*) is considered a BSR herbicide belonging to the pyrimidine carboxylic acid class of herbicides, a new class of herbicide chemistry. This product is reported to have a half-life in soil averaging 129 days.[1] The extended control offered by this product would make it well suited to this application. However, MAT28 is selective to grasses and a tank mix partner is necessary to provide the weed species spectrum of control required for bareground applications. The active ingredient, *aminocyclopyrachlor* is not sold alone for the right-of-way market; however, Streamline is a premix of MAT28 plus Escort (*metsulfuron*) and a PennDOT custom blended formulation of these two active ingredients is available for this application.

Preemergence herbicides which in some instances provide a level of postemergence activity include: *Oxyfluorfen* (Goal 2XL), a cell membrane disrupter with contact herbicide activity is uncommon on the roadside but is effective for control of emerging seedlings; *Rimsulfuron* (Matrix), an ALS inhibitor with many species, including kochia, developing resistance to this class of chemistry; [2] *Pendimethalin* (Prowl) and *oryzalin* (Surflan), both cell-division or root inhibitors acting only on germinating seeds; both *sulfentrazone* (Authority) and *flumioxazin* (Valor) are PPO-inhibitors used to control germinating annual weeds and as a burndown; and *Indaziflam* (Specticle) a new cellulose biosynthesis inhibitor that works as a preemergence herbicide.

MAT28 was applied in combination with *glyphosate* and the above-described preemergence herbicides to evaluate the effectiveness of providing season-long control of vegetation.

MATERIALS AND METHODS

The trial site was located under a guiderail along I-99 N near Port Matilda, PA. Fourteen treatments included glyphosate alone at 64 oz/ac; MAT28 (SG 50%) alone at 6 oz/ac or mixed with either Matrix at 4 oz/ac, Karmex at 64 oz/ac, Authority at 5.33 oz/ac, Goal 2XL at 64 oz/ac, Valor at 8 oz/ac, Surflan AS at 96 oz/ac, or Prowl at 64 oz/ac; Prowl at 64 oz/ac mixed with Authority at 5.33 oz/ac; PennDOT Custom Blend (MAT28 at 7.67 plus Escort XP at 0.33 oz/ac) or Streamline (MAT28 at 6.3 oz/ac plus Escort XP at 1.7 oz/ac) plus Specticle at 5 oz/ac; Karmex at 128 oz/ac plus Oust XP at 3 oz/ac; and an untreated check. For this experiment, several herbicide substitutions were made by the supplier due to product availability. These substitutions were of products with similar percentage active ingredients but not labeled for non-crop applications and included: Specticle 20 WSP, labeled for landscape use in place of Esplanade 200SC with the active ingredient *indaziflam*; Prowl, labeled for crop use in place of Pendulum 3.3EC with the a.i. *pendimethalin*; and Valor labeled for crop and non-crop farm use in place of Payload with the a.i. *flumioxazin*. All treatments included Roundup Original Max at 64 oz/ac and Induce non-ionic surfactant at 0.25% v/v. The treatments were applied to 5 by 20 ft plots with three replications at 50 gal/ac on April 21, 2011 using a CO_2-powered backpack

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[1] U.S. Environmental Protection Agency, Registration of the New Active Ingredient Aminocyclopyrachlor for Use on Non-Crop Areas, Sod Farms, Turf, and Residential Lawns. p. 14. Aug 24, 2010. June 1, 2012. <http://www.google.com/search?client=safari&rls=en&q=aminocyclopyrachlor+half-life&ie=UTF-8&oe=UTF-8>

[2] Heap, I. International Survey of Herbicide Resistant Weeds. Online. Internet. June 01, 2012. Available www.weedscience.com

sprayer equipped with an ultra low volume wand and Spraying Systems Boomjet XP25L spray tip. The first rainfall occurred nearly 26.5 hours following treatment with total precipitation amounts of approximately 0.31 inches.

The study was visually rated for total vegetative cover on April 21, May 23, June 25, July 21, August 23, and October 15, 2011, which corresponds to 0, 32, 65, 91, 124, and 177 days after treatment, DAT. Percent control was also assessed on May 20, June 25, July 21, August 23, and October 15, 2011 that corresponds to 29, 65, 91, 124, and 177 DAT.

RESULTS AND DISCUSSION

At the initial evaluation, 29 DAT, control ranged from 93 to 100 percent for the herbicide treatments with glyphosate and MAT28 alone being significantly lower than the best performing treatments at 93 percent (Table 1). The percent control declined or remained constant over the period of evaluation for all herbicide treatments. By 177 DAT, overall control ranged from 23-100%. Glyphosate and MAT28 alone, in addition to MAT28 plus Matrix or Karmex were similar to the untreated check with control ratings of 23 to 52 percent. All other herbicide combinations provided 87 to 100 percent control. At 177 DAT, the greatest amount of vegetative cover was recorded for the untreated check at 33%. Over the course of the experiment, we found that the overall weed pressure at this site was not strong. Treatments with MAT28 or glyphosate alone averaged 27 and 17 percent cover, respectively.

Previous experiments have shown that tank mixes of MAT28 plus Surflan AS or *pendimethalin* can provide excellent season-long bareground weed control.[3] In the present trial, these mixes were among the best performing treatments with 95 percent control at 177 DAT. Combinations of MAT28 plus Authority, Goal 2XL, or Valor (*flumioxazon*) provided excellent control at 87 to 93 percent; however, in previous experiments these combinations provided mediocre control through the growing season.[3] *Pendimethalin* plus Authority or the standard, Karmex plus Oust XP, produced 92 and 97 percent control, respectively. These combinations were among the top performing treatments.

The PennDOT Custom Blend and Streamline are both combinations of MAT28 plus Escort XP at differing percentages. Either product combined with *indaziflam* provided complete control of vegetation (i.e., 100 percent) for the length of the investigation.

CONCLUSIONS

MAT28 plus Surflan or *pendimethalin* have provided excellent bareground weed control in two separate experiments. Though MAT28 plus Authority, Goal 2XL, or Valor (*flumioxazin*) were effective in this trial, they have not been among the best treatment combinations in the past. Based on these experiments, *Pendimethalin* plus Authority and the PennDOT Custom Blend or Streamline plus *indaziflam* appear to be effective in providing season-long bareground weed control, but should be further tested to confirm these results using the appropriate non-crop labeled products.

[3] Johnson, J.M. et al 2011. MAT28 in combination with preemergence herbicides for season-long bareground weed control. Roadside Vegetation Management Research Annual Report. p 49-53.

MANAGEMENT IMPLICATIONS

Tank mixes of MAT28 and Surflan or *pendimethalin* offer potential for bareground weed control treatments. MAT28, or *aminocyclopyrachlor*, is currently available on the Pennsylvania State Herbicide Contract only as the PennDOT Custom Blend or Streamline products evaluated in this experiment. Either product adds *metsulfuron* to the mix, which will enhance the spectrum of activity, especially postemergence. The addition of Surflan or *pendimethalin* to either product containing MAT28 would be a fitting choice. However, Surflan and *pendimethalin* should be used with caution in highly visible areas where short-term staining (i.e., days) of pavement and other structures, such as guiderails, is a concern.

Table 1. Percent control was visually rated on May 20 (29 days after treatment, DAT), June 25 (65 DAT), July 21 (91 DAT), August 23 (124 DAT), and October 15, 2011 (177 DAT). All herbicide treatments included Roundup Original Max at 64 oz/ac and were applied to a roadside guiderail location near Port Matilda, PA on April 21, 2011. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Control				
Treatment	Rate	29 DAT	65 DAT	91 DAT	124 DAT	177 DAT
	(oz/ac)	(----------------------------------%----------------------------------)				
untreated	---	0 a	0 a	0 a	0 a	0 a
Glyphosate	64	93 b	75 b	72 bc	65 ab	42 ab
MAT 28	6	93 bc	70 b	53 b	38 ab	23 a
Mat 28 Matrix	6 4	99 bc	79 b	81 bc	60 ab	50 ab
MAT 28 Karmex	6 64	97 bc	80 b	79 bc	60 ab	52 ab
MAT 28 Authority	6 5.33	99 bc	96 b	91 bc	93 b	87 b
MAT 28 Goal 2XL	6 64	100 c	99 b	99 c	98 b	93 b
Mat 28 Valor*	6 8	100 c	99 b	99 c	97 b	93 b
MAT 28 Surflan AS	6 96	100 c	99 b	99 c	98 b	95 b
MAT 28 Prowl*	6 64	100 c	99 b	98 bc	98 b	95 b
Prowl* Authority	64 5.33	99 bc	99 b	94 bc	94 b	92 b
PennDOT Custom Blend Specticle*	8 5	100 c	100 b	100 c	100 b	100 b
Streamline Specticle*	8 5	100 c	100 b	100 c	100 b	100 b
Karmex Oust XP	128 3	100 c	99 b	99 c	99 b	97 b

* Products with an asterisk are not labeled for non-crop right-of-way usage and were provided by the supplier as a substitution for the non-crop labeled products due to availability. The percent active ingredients are similar and were applied to ensure that similar non-crop rates were applied.