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DEPARTMENT OF TRANSPORTATION

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ROADSIDE VEGETATION MANAGEMENT RESEARCH REPORT
SIXTEENTH YEAR REPORT

THE PENNSYLVANIA STATE UNIVERSITY
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The sixteenth year report on a cooperative research project between the Pennsylvania Department of Transportation, Bureau of Maintenance and Operations; and the Pennsylvania State University, College of Agricultural Sciences; including:
Brush control research evaluating dormant stem and foliar herbicide applications.
Evaluation of Thinvert for low volume foliar applications.
Selective control of Canada thistle in crownvetch.
Effect of herbicide and application timing on poison hemlock.
Comparing various glyphosate formulations and Garlon 3A mixtures for control of herbaceous perennials.
Evaluation of Derringer, Glyphosate, Milestone VM, Imazapic:Glyphosate premix and other herbicides for bareground weed control.
Controlling Kochia and Sand Dropseed in bareground sites.
Evaluation of companion species used in native grass-based mix.
Review of 2001 Roadside Vegetation Management Conference Field Day.

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The contents of this report represent the views of the authors, who are solely responsible for its content. These views do not represent the views of The Pennsylvania State University, The Pennsylvania Department of Transportation, or The Commonwealth of Pennsylvania. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

In October, 1985, personnel at The Pennsylvania State University began a cooperative research project with the Pennsylvania Department of Transportation to investigate several aspects of roadside vegetation management. An annual report has been submitted each year which describes the research activities and presents the data. The previous reports 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

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Tenth Year Report

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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

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Fourteenth Year Report

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

Use of Statistics in This Report

Many of the individual reports in this document make use of statistics, particularly techniques involved in the analysis of variance. The use of these techniques allows for the establishment of a criteria for significance, or, when the differences between numbers are most likely due to the different treatments, rather than due to chance. We have relied almost exclusively on the commonly used probability level of 0.05. When a treatment effect is significant at the 0.05 level, this indicates that there is only a five percent chance that the differences are due to chance alone. At the bottom of the results tables where analysis of variance has been employed, there is a value for least significant difference (LSD). An LSD value is reported only when the analysis of variance demonstrates that the treatment effect is significant. This is a 'protected' LSD, which is a more conservative approach. When there is a large number of treatments, an LSD can indicate significant differences between treatments even if the treatment effect was not significant in the analysis of variance. When the difference between two treatment means is equal or greater than the LSD value, these two values are significantly different. When the treatment effect is not significant in the analysis of variance, the LSD value is reported as 'n.s.', indicating non-significant.

This report includes information from studies relating to roadside brush control, herbaceous weed control, roadside vegetation management demonstrations, and total vegetation control under guiderails. 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 name, active ingredients, formulation, and manufacturer information for products referred to in this report.

Trade Name	Active Ingredients	Formulation	Manufacturer
Accord	glyphosate	4 S	Monsanto
Arborchem Basal Oil	diluent	- - -	Arborchem Products, Inc.
Arsenal	imazapyr	2 S	BASF Specialty Products
Basagran T/O	bentazon	4 S	TopPro Specialties
2,4-D Amine	2,4-D	3.76S	Helena Chemical Co.
Derringer	glufosinate-ammonium	1S	Aventis Environ. Sci. USA LP
Endurance	prodiamine	65 WG	Novartis Crop Protection, Inc.
Escort	metsulfuron methyl	60 DF	E.I. DuPont de Nemours & Co.
Garlon 3A	triclopyr	3 S	DowAgroSciences LLC
Garlon 4	triclopyr	4 EC	DowAgroSciences LLC
Glyphosate	glyphosate	4S	E.I. DuPont de Nemours & Co.
Glypro	glyphosate	5.4S	DowAgroSciences LLC
Hyvar X	bromacil	80WP	E.I. DuPont de Nemours & Co.
Karmex	diuron	80 DF	E.I. DuPont de Nemours & Co.
Krenite S	fosamine ammonium	4 S	E.I. DuPont de Nemours & Co.
Krovar I	bromacil + diuron	80 DF	E.I. DuPont de Nemours & Co.
Milestone VM	azafeniden	80 DG	E.I. DuPont de Nemours & Co.
Oust	sulfometuron methyl	75 DF	E.I. DuPont de Nemours & Co.
Pendulum	pendimethalin	3.3 EC	BASF Specialty Products
Plateau	imazapic	2 S	BASF Specialty Products
Pursuit	imazethapyr	- - -	BASF Corporation
QwikWet 357	adjuvant	- - -	Exacto Chemical Company
Rodeo	glyphosate	5.4S	Monsanto
Roundup Pro Dry	glyphosate	71.4 DG	Monsanto
Sahara	diuron + imazapyr	DG	BASF Specialty Products
Simazine	simazine	4L	UAP Platte Chemical Co.
Spike	tebuthiuron	20P, 80W	DowAgroSciences LLC
Stalker	imazapyr	2 EC	BASF Specialty Products
Surflan	oryzalin	4 AS	DowAgroSciences LLC
Telar	chlorsulfuron	75DF	E.I. DuPont de Nemours & Co.
Thinvert RTU	invert emulsion	- - -	Waldrum Specialties, Inc.
Tordon K	picloram	2 S	DowAgroSciences LLC
Tordon 101M	picloram + 2,4-D	2.5S (0.5+2)	DowAgroSciences LLC
Touchdown Pro	glyphosate	3S	Syngenta Professional Products
Transline	clopyralid	3 S	DowAgroSciences LLC
Vanquish	dicamba-glycolamine	4 S	Novartis Crop Protection, Inc.
Velpar DF	hexazinone	75DF	E.I. DuPont de Nemours & Co.
Velpar L	hexazinone	2 S	E.I. DuPont de Nemours & Co.
Vista	fluroxypur	1.5S	Dow AgroSciences LLC

CONTROLLING BRUSH WITH DORMANT STEM APPLICATIONS OF ESCORT AND GARLON 4

Herbicide trade and common chemical names: Escort (*metsulfuron*), Garlon 4 (*triclopyr*).
Plant common and scientific names: crownvetch (*Coronilla varia*), gray birch (*Betula populifolia*), green ash (*Fraxinus pennsylvanica*), hickory (*Carya* spp.), pin cherry (*Prunus pensylvanica*), poplar [mixture of bigtooth aspen (*Populus grandidentata*) and trembling aspen (*Populus tremuloides*)], red maple (*Acer rubrum*), red oak (*Quercus rubra*), sassafras (*Sassafras albidum*), and wild radish (*Raphanus raphanistrum*).

ABSTRACT

Dormant stem treatments using Escort and Garlon 4 were applied to a mixed species stand of brush resprouts. Escort alone at 1 oz/100 gal was the least effective treatment, providing 36 percent growth reduction averaged over all species. Increasing the Escort rate to 3 oz/100 gal significantly increased growth reduction to 66 percent. Adding Escort to Garlon 4 did not improve growth reduction compared to Garlon 4 alone, regardless of Escort rate or Garlon 4 rate. Increasing Garlon 4 rate from 1 percent (v/v) to 2 percent improved control of pin cherry from 69 to 93 percent, but did not signficantly improve overall control-86 and 91 percent, respectively.

INTRODUCTION

Dormant stem applications have been periodically evaluated because they offer an opportunity to chemically treat trees and brush at a time of year when treatment options are limited. Dormant stem treatments are an option when brush is relatively small and dense, and therefore unsuitable for basal bark or cut surface treatments. Dormant stem treatments are similar in approach to foliar treatment, except that the bark of the entire plant is targeted. Because there are no leaves to intercept the spray, much of it has the potential to pass by the target. Backpack applications can be more precisely targeted than using traditional high volume equipment, but make for a laborious application as density and brush size increases.

Another advantage to dormant season treatments is that much of the herbaceous understory is also dormant. This can result in less damage to the desirable groundcover. Dormant timings also would significantly limit potential non-target issues with adjacent properties.

Garlon 4 is regarded as the standard ingredient in dormant stem treatments due to its oil soluble formulation that enhances bark penetration, and demonstrated efficacy against a broad spectrum of woody species. This trial evaluated the effect of adding Escort to Garlon 4 mixtures.

MATERIALS AND METHODS

The study was established along the SR 81 N shoulder at the Dorrance exit in Luzerne county. Treatments were applied on April 20, 2000 to a mixed stand of resprouts from a clearing operation in the winter of 1998/1999. Target species included pin cherry, poplar species, gray birch, sassafras, red maple, red oak, green ash and hickory. At the time of treatment, pin cherry and poplar were beginning to leaf-out while the other species were not beyond bud swell. Targets ranged from 2 to 10 feet tall. Poplars were generally the largest, cherry ranged from 3 to 5 ft tall, and ash and oaks were 2 to 3 ft tall.

Treatments were based on a dosage per 100 gal, and included Escort alone at 1 or 3 oz; Garlon 4 alone at 128 or 256 oz; Escort at 1 or 3 oz in combination with Garlon 4 at 128 oz, and Escort at 1 oz plus Garlon 4 at 256 oz. All treatments included a crop oil concentrate at 384 oz/100 gal (3 percent , v/v). These treatments were applied using backpack sprayers equipped with ULV basal wands and Spraying Systems #5500 Adjustable ConeJets with X-6 tips. Spray coverage involved lightly wetting the canopy branches and more thoroughly wetting the primary stem. Smaller stems were targeted from one side and larger clusters received complete coverage. The study was arranged in a randomized complete block design with three replications. Plot size ranged from 960 to 3320 sq. ft, and varied based on number of targets. Average application volume was determined for each plot, and averaged 21 gal/ac with a range from 7 to 34 gal/ac.

Ratings of growth reduction by species was taken on August 28, 2000, 130 days after treatment, and were based on untreated areas adjacent to the study. Data for pin cherry, red maple, and the average for all species were subjected to analysis of variance.

RESULTS AND DISCUSSION

Treatment effect was significant ($p \leq 0.05$) for pin cherry and average control, and nearly significant for red maple ($p=0.06$).

The pin cherry results showed the treatments falling into three performance groups (Table 1). Escort alone at 1 oz was ineffective (37 percent), Escort alone at 3 oz or combinations including Garlon 4 at 128 oz were significantly better but not operationally acceptable (63 to 73 percent), and the treatments including Garlon 4 at 256 oz were effective (90 to 93 percent).

Escort alone at 1 oz was least effective against red maple (47 percent), and provided significantly less control than all treatments except Escort alone at 3 oz. There were no significant differences between the remainder of the treatments, which ranged from 62 to 91 percent growth reduction.

When the treatments were evaluated for total control, Escort alone at 1 oz provided the least control (36 percent), which was significantly lower control than any other treatment. Plots treated with Garlon 4 at 256 oz were rated highest for growth reduction at 91 percent. This was not significantly different than Garlon 4 alone at 128 oz. Adding Escort at 1 oz to Garlon 4 at 256 oz, or adding Escort at 1 or 3 oz to Garlon 4 at 128 oz did not provide an increase in control.

Target size influenced control ratings, particularly for cherry and birch as smaller stems were visibly more affected than larger stems. A substantial understory of goldenrod species was present. Two weeks after application, wild radish and crownvetch were showing visible injury symptoms from all treatments. Though the treatments affected herbaceous species that were present at the time of application, later-emerging species did not appear to be inhibited.

CONCLUSIONS

Adding Escort to Garlon 4 did not improve control. The best treatments were almost operationally acceptable. An increase in application volume and evaluation of some tank mix ingredients would probably produce a treatment that would provide effective control.

MANAGEMENT IMPLICATIONS

If the biggest limitation facing the Department was season length, rather than funding, dormant stem treatments would be worthy of further evaluation. These treatments can extend the available management window, and help keep effective contract crews working.

Table 1. Brush response to treatments applied April 20, 2000. Percent growth reduction was rated on August 28, 2000 for each species present within the plot. Each value is the mean of three replications. Only data from species present in all plots was subjected to analysis of variance.

Application		--------------------------------Growth Reduction-----------------------------					
Product	Rate	Pin Cherry	Red Maple	Grey Birch	Red Oak	Green Ash	Average
	oz/100 gal	%	%	%	%	%	%
Escort	1	37	47	23	55	50	36
Escort	3	63	62	20	63	77	66
Escort Garlon 4	1 128	70	82	73	70	78	74
Escort Garlon 4	3 128	73	77	20	85	72	76
Escort Garlon 4	1 256	90	89	86	91	99	88
Garlon 4	128	69	91	85	82	93	86
Garlon 4	256	93	88	83	91	93	91
LSD (p=0.05)		23	30	---	---	---	14

CONTROL OF TREE-OF-HEAVEN PROVIDED BY FOLIAR HERBICIDE APPLICATIONS

Herbicide trade and common chemical names: Arsenal (*imazapyr*), Escort (*metsulfuron*), Garlon 3A (*triclopyr*), Krenite S (*fosamine*), Roundup Pro Dry (*glyphosate, ammonium salt*), Touchdown Pro (*glyphosate, diammonium salt*).
Plant common and scientific names: Tree-of-heaven or ailanthus (*Ailanthus altissima*), crownvetch (*Coronilla varia*), giant foxtail (*Setaria faberi*), Japanese honeysuckle (*Lonicera japonica*).

ABSTRACT

Foliar herbicide applications made in August to ailanthus provided at least 94 percent control of treated stems and almost complete suppression of resprouts, when evaluated the following season. Herbicide treatments included Escort at concentrations of 0.5, 1.0, or 1.5 oz per 15 gal for low volume applications, and mixed per 100 gal for high volume applications; and high volume applications with two different glyphosate formulations. The ammonium (Roundup Pro Dry) and diammonium (Touchdown Pro) salts of glyphosate were applied alone concentrations of 3.0 or 4.5 lb acid equivalent (ae) per 100 gal, or at 3.0 lb ae in combination with Garlon 3A at 64 oz/100 gal; Arsenal at 8 oz/100 gal; or Escort at 1.0 oz/100 gal. There were no significant differences between any treatments.

INTRODUCTION

Tree-of-heaven, or ailanthus, is a fast-growing, weak-wooded, clonal tree species that is well adapted to highly disturbed soils characteristic of highway corridors. The presence of ailanthus in the ROW poses an acute threat to motorists, and its rapid spread makes progressive management a priority activity. In 2000, the Penn State project was approached by two herbicide manufacturers that wanted their products tested in stands of ailanthus. The herbicide manufacturer DuPont is actively seeking specific label recommendations for ailanthus control for the herbicide Escort. A range of rates were evaluated, applied at low or high volumes and compared to a standard treatment. The manufacturer Syngenta (formerly Zeneca and CIBA) has a new liquid formulation of glyphosate as a diammonium salt, called Touchdown Pro, and is seeking efficacy data compared to existing glyphosate formulations in a variety of non-crop settings.

The most familiar glyphosate formulation is the isoproplyamine (IPA) salt, which is the active ingredient in formulations such as Roundup Pro, Rodeo, Accord, DuPont Glyphosate, GlyPro, GlyPro Plus, or GlyphoMate 41. Alternate glyphosate formulations have recently been introduced to the non-crop market. Roundup Pro Dry is a water-soluble granulated powder containing the ammonium salt of glyphosate, and contains 64.9 percent glyphosate acid. Touchdown Pro is a diammonium salt formulation containing 3 lbs of glyphosate acid per gallon. This is the same concentration of glyphosate acid as familiar products such as Roundup Pro or DuPont Glyphosate. The diammonium salt molecule is much smaller than the isopropylamine molecule, so even though there is less of the *glyphosate-salt* on a weight basis compared to the IPA salt formulations, there is the *same amount of glyphosate acid* per gallon.

MATERIALS AND METHODS

Escort Trial

This trial was established on a cut-slope on SR 22, near Newport, PA, on August 16. Escort was mixed at 0.5, 1.0, or 1.5 oz per 15 gal for low volume applications, and per 100 gal for high volume applications. Krenite S plus Arsenal at 96 oz plus 9.6 oz/ac, respectively, applied at 15 gal/ac was used as a standard. All treatments included an organosilicone-based non-ionic surfactant at 0.1 percent, v/v. High volume applications were made with a truck-mounted sprayer, equipped with a John Bean R10 piston pump, a Spraying Systems GunJet AA2AL with an AY-SS 90 spray tip, and 120 ft of 0.5 in hose. Operating pressure was 120 to 150 psi at the pump. Low volume applications were made with a lever-actuated, piston pump backpack equipped with a Spraying Systems GunJet 30 with a #5500 Adjustable ConeJet with a Y-2 tip. The targeted tree-of-heaven was regrowth from a winter 1997/98 cutting operation, and ranged from 1 to 20 ft tall, with an average height of 10 ft. Plot dimensions varied, but treated plot area was approximately 0.1 ac/plot. All brush in high volume plots was treated, while low volume treatments were limited to trees shorter than 15 ft. Trees that were treatable or untreatable in the low volume plots occurred in contiguous patches, so there was not intermingling of treated and untreated stems. Ratings were conducted for canopy reduction on October 11, 2000, and for percent control on June 19, 2001.

Glyphosate Formulation Trial

The second trial evaluated high volume applications of two glyphosate formulations: the ammonium salt, Roundup Pro Dry; and the diammonium salt, Touchdown Pro. Roundup Pro Dry and Touchdown Pro were each applied alone at 3.0 (72 or 128 oz/ac, respectively) or 4.5 (108 or 192 oz/ac, respectively) lb acid equivalent (ae)/100 gal. Each formulation was applied at 3 lb ae/100 gal in combination with Garlon 3A at 64 oz/100 gal, Arsenal at 8 oz/100 gal, or Escort at 1 oz/100 gal. No surfactant was added, as both glyphosate formulations are surfactant-loaded. Treatments were applied August 22, 2000, to a highway cut-slope at the interchange of SR 26/550 near Bellefonte, PA, using a motorized backpack sprayer equipped with a Spraying Systems GunJet 30 with a #5500 ConeJet nozzle with an X-12 tip. Plots were established along the front of an extensive stand, and measured about 40 ft long. Plot depth was 10 to 15 ft, depending upon tree height, which directly affected the reach of the spray equipment. Canopy reduction was rated October 9, 2000, and August 23, 2001.

RESULTS AND DISCUSSION

Percent control in 2001 was 99 percent or greater for all treatments in the Escort trial, and no ailanthus resprouting was observed. In the high-volume plots, the groundcover, usually crownvetch or Japanese honeysuckle, was largely eliminated and regrowth was suppressed when rated in June 2001. By the end of 2001 growing season the Escort-treated areas had mostly revegetated, primarily with giant foxtail.

Control ratings were between 94 and 99 percent for all treatments in the glyphosate formulation trial, and resprouting ranged from 1 to 5 percent on a percent cover basis at Bellefonte, where the plots were on the front edge of a large, still intact ailanthus clone.

CONCLUSIONS

Foliar applications based on the herbicides Escort or glyphosate are highly effective against tree-of-heaven. Low volume applications are preferred where target conditions permit because of the reduced damage to the understory and adjacent non-target due to the greater selectivity of this approach.

MANAGEMENT IMPLICATIONS

Where well-established infestations of ailanthus exist, the Department will be forced to balance the efficacy, productivity, and selectivity of control methods. High volume foliar applications are highly effective and productive, but less selective to the understory and immediately adjacent non-target plants than low volume foliar applications, basal bark, or cut-and-stump-treatment.

Where infestations are severe and well-established, high-volume treatments could serve as the first step in a multiple-phase control program. Relying solely on high-volume treatments will cause misses of tall trees and unacceptable understory damage where scattered, small ailanthus stems exist. Treating the most viable targets with high-volume and following up with more selective techniques such as basal bark, cut-and-stump-treat, or low-volume foliar will be a preferable approach.

COMPARISON OF WATER AND THINVERT AS CARRIERS FOR LOW VOLUME FOLIAR APPLICATIONS OF KRENITE S TO TREE-OF-HEAVEN

Herbicide trade and common chemical names: Krenite S (*fosamine ammonium*), Arsenal (imazapyr).
Plant common and scientific names: Tree-of-heaven or ailanthus (*Ailanthus altissima*), boxelder maple (*Acer negundo*), sassafras (*Sassafras albidum*).

ABSTRACT

Krenite S was applied at 3, 5, or 8 percent, v/v, using water or Thinvert as a carrier for low volume foliar treatment of tree-of-heaven. Estimated application rates were 29 gal/ac for aqueous, and 11.5 gal/ac for Thinvert treatments. Increasing Krenite concentration in the aqueous treatments resulted in significant increases in ratings of canopy reduction. Canopy reduction with aqueous treatments was 13, 40, and 75 percent, at Krenite concentrations 3, 5, 8 percent v/v, respectively. Thinvert treatments were less consistent, and appeared to be more sensitive to target size. When treatments were compared based on estimated Krenite application rate, Thinvert treatments provided greater activity per unit dosage of Krenite.

INTRODUCTION

Thinvert is a proprietary formulation of non-phytotoxic paraffinic oils, surfactants, and emulsifiers that forms a thin invert emulsion. This product is applied with specially designed nozzles that provide nearly uniform droplet size. The uniform droplet size increases applicator control of the deposition of the spray, and the white color and somewhat-viscous nature of the droplets makes them easy to see on plant foliage. This combination of properties allows Thinvert to serve as an effective carrier at spray volumes as low as 5 gal/ac. The oily nature and very low application volumes ensure retention of leaf foliage. Currently, Thinvert costs the end-user about $8/gal. Comparing the utility of Thinvert to water, which is nearly free, is not necessarily simple. Factors such as cost per acre and acres covered per hour are straightforward concepts. Considerations such as needing to carry less weight per unit treatment area would effect both backpack and vehicle-based applications, and could impact both applicator comfort and effectiveness, as well as spray vehicle size and cost. Thinvert does have a foothold in the non-crop market, and there are applicators that prefer using Thinvert to water. Though not always explicitly touted, recommended herbicide rates for Thinvert applications are often lower on a per acre basis compared to aqueous applications. For example, based on Department usage patterns, the current application rate for sidetrimming using Krenite S (Krenite) in Thinvert is 128 oz/ac, plus 2 to 6 oz/acre of Arsenal. The aqueous application rates for Krenite is 192 oz/ac plus 1 to 4 oz/ac of Arsenal.

Krenite is typically used to chemically side trim larger trees along highway rights-of-way, and provide complete control of smaller trees. When applied to deciduous trees during the latter part of the growing season, it inhibits bud break in the treated branches the following spring. In this way, it stops the formation of leaves on those branches and clears the roadside of sight distance and shading problems without destroying the tree.

The objective of this trial was not to determine the use rate alone for Krenite against ailanthus, but to use Krenite as a tool to evaluate the effects of carrier type and concentration on brush injury. Using Krenite S alone is not a recommended practice, as there are species such as boxelder maple and sassafras that are not effectively inhibited at common use rates. Using

Krenite alone in an efficacy trial provides the advantage that a properly selected rate spectrum will range from ineffective to highly effective. The effects of varying efficacy will be somewhat easy to visualize as decreasing efficacy results in a shorter distance between the terminal bud and the onset of bud break further down the stem. Using a largely unbranched species like ailanthus resprouts makes this characterization even simpler.

MATERIALS AND METHODS

The study was established on the infield area of the SR 22/SR 34 interchange in Perry County. This area was infested with 25 to 30 ft ailanthus that had been brushed during the winter of 1997/1998, and resprouts were spot-treated in September 1998. In 2001, resprouts were up to 15 feet, with some being almost beyond a reasonable height for targeting with low volume application methods. Treatments included Krenite S at 3, 5, or 8 percent v/v using either water of Thinvert RTU as a carrier. Where water was used as a carrier 0.1 % v/v Qwikwet 357, an organosilicone surfactant, was added. The study site was arranged in a randomized complete block design with a factorial treatment arrangement with three replications. Treatments were made August 17, 2000 using a backpack sprayer equipped with either a Spraying Systems #5500 Adjustable Conejet nozzle with a Y-2 tip for aqueous applications, or a 71510 Thinvert nozzle for the Thinvert treatments. Plot dimensions were variable in an attempt to equalize the number of stems per plot over an area with varying size and density of targets. Where the plots were solid brush canopy, the treatment area was approximately 1000 ft^2.

A total of 14.75 liters of solution was sprayed for the three aqueous treatments, and a total of 7.0 liters was used for the three Thinvert treatments. Based on comparisons of similar, adjacent plots that had a nearly continuous brush canopy, the application volume for aqueous treatments was 29 gal/ac, and 11.5 gal/ac for Thinvert treatments. This gives estimated Krenite S application rates, in gallons/ac, of 0.35, 0.57, and 0.92 for the Thinvert treatments of 3, 5, and 8 percent, respectively; and 0.87, 1.45, and 2.3 for aqueous treatments of 3, 5, and 8 percent, respectively. These must be regarded as rough estimates.

Percent canopy reduction ratings were taken June 19, 2001, 283 days after treatment (DAT). The data were subject to analysis of variance

RESULTS AND DISCUSSION

Table 1 reports ailanthus canopy reduction based on treatments by concentration and carrier. Table 2 reports control results based on estimated Krenite dosage.

There was a significant interaction between the effects of carrier and herbicide concentration. Patterns from the data were skewed by the ratings for the 8 percent concentration of Krenite in Thinvert, which averaged 35 percent canopy reduction, while the 5 percent concentration in Thinvert was rated at 57 percent canopy reduction. In contrast, the ratings of canopy reduction increased with concentration for the aqueous treatments, and each increase in concentration produced a significant increase in canopy reduction (Table 1).

When the results are reviewed in terms of estimated dosage, Thinvert provides greater efficacy per unit dosage, particularly at the two lower Krenite concentrations (Table 2).

We believe the variability in the Thinvert results is due to the variability of ailanthus size and density between plots, and that the Thinvert application results were more affected by the target size and density than the aqueous treatments. This may be more an issue of the applicators being unwilling to seemingly over-apply the Thinvert treatments, rather than being able to actually achieve the needed dosage at the top of the taller targets. The equipment we were using did not limit our ability to reach the targets with Thinvert, but we may not have been able to reach the tops of the taller targets with what we considered to be the target coverage of 5 gal/ac. Therefore, we probably under dosed these targets for fear of overdosing them.

CONCLUSIONS

This trial provides evidence that using Thinvert increases efficacy of Krenite. More rigorous experimentation will be required to verify this. These results also demonstrate the necessity to tank mix other herbicides with Krenite to achieve effective control of ailanthus.

MANAGEMENT IMPLICATIONS

The Department should continue its current trend of expanding the uses of Thinvert. The controlled-deposition qualities of Thinvert improve the applicators ability to precisely target their application and avoid non-target injury. If it can be reliably demonstrated that Thinvert allows for reduced herbicide rates, then the issue of paying $40/ac for carrier is lessened by herbicide cost savings, as well as greater productivity due to less mixing.

Thinvert is a viable tool for the Department, and has utility in both truck-based and backpack applications. The Department and the research project should continue to investigate the extent of its utility.

Table 1. Response of ailanthus to foliar treatments of Krenite S, applied with water or Thinvert as the carrier. Treatments were applied September 9, 2000, and canopy reduction was evaluated June 19, 2001. Each value is the mean of three replications.

		Canopy Reduction	
	Concentration	Water	Thinvert
	% v/v	----------- %	-----------
Krenite S	3	13	13
Krenite S	5	40	57
Krenite S	8	75	35
LSD (p=0.05)		22	n.s.

Table 2. Response of ailanthus to foliar treatments of Krenite S. Treatments were applied September 9, 2000, and canopy reduction was evaluated June 19, 2001. Krenite dosages are based on an estimated application rate of 11.5 gal/ac for Thinvert treatments, and 29 gal/ac for aqueous treatments. Each value is the mean of three replications.

Carrier	Krenite S Concentration	Estimated Application Rate	Canopy Reduction
	%	oz product/ac	%
Thinvert	3	45	13
Thinvert	5	73	57
Thinvert	8	117	35
Water	3	112	13
Water	5	186	40
Water	8	295	75

UNEXPECTED DECLINE OF CANADA THISTLE IN A TRIAL EVALUATING SELECTIVE CONTROL IN CROWNVETCH-MORE QUESTIONS THAN ANSWERS

Herbicide trade and common chemical names: Velpar (*hexazinone*), Plateau (*imazapic*), Basagran T/O (*bentazon*).
Plant common and scientific names: Canada thistle (*Cirsium arvense*), crownvetch (*Coronilla varia*).

ABSTRACT

This investigation of spring and fall applications of selective herbicide treatments to control Canada thistle in crownvetch had to be abandoned after the thistle population fell to near zero, even in untreated plots. We believe this was due to the impact of herbicide trials conducted on this site in each of the three years previous to initiating this trial. Each of the previous trials failed to identify treatments that provided effective control of Canada thistle and the population still seemed quite vigorous at the initiation of this trial. However, our records reveal that average Canada thistle stem counts for the site per 90 ft^2 were 112, 113, 105, 39, and 3.6, in 1997 through 2001, respectively. The decline from 105 to 39 stems per plot was counted in the same plots, and this decline occurred in untreated plots as well.

With no observations of the ongoing condition of the Canada thistle root system, we cannot describe how the thistle decline progressed, as there was no above-ground sign other than stem counts that we observed.

INTRODUCTION

Canada thistle thrives in the roadside environment, and often coexists with crownvetch making selective control nearly impossible with approaches used to date. Past efforts to selectively remove Canada thistle from crownvetch produced a short list of available herbicides: Velpar, Basagran T/O (Basagran), and more recently Plateau. Velpar and Basagran are primarily burn-down materials, and Basagran only was suitable in a tank mix with Velpar as it controlled a very narrow species spectrum of established weeds. Our previous efforts with Plateau showed effective control of treated shoots, but resprouting was significant compared to other systemic herbicides. From our efforts from 1985 through 1992 we came to believe that ongoing repeat treatments would be necessary Since the early 1990's we have favored removal of both Canada thistle and crownvetch, and re-establishing the affected areas to a fineleaf fescue mixture (seeding Formula L, Publication 408). However, we have seen that these grass areas can be overrun by crownvetch. The change of groundcover changed the weed species, but in some cases it may be difficult to demonstrate that the maintenance effort was lessened. This led us to reconsider the approach of trying to selectively control Canada thistle in crownvetch. If repeated maintenance would be required, annual herbicide applications over a finite period might be a viable alternative to reestablishment with periodic maintenance applications.

A protocol was developed to evaluate using Velpar and Plateau, alone or together, applied in spring and/or fall. Plateau is a systemic herbicide, and fall applications would have the potential for greater effect on the Canada thistle root system. Conversely, Canada thistle is most problematic in the spring when it grows to its greatest height and produces its windborne seed. The intent was to repeat the trial over a number of years, and determine if any of the treatments could cause a meaningful reduction in Canada thistle.

MATERIALS AND METHODS

This study was established on a southwest facing, cut slope with limestone bedrock located along the SR 322 westbound entrance ramp of SR 45. The treatments are listed in Table 1. The study was arranged in a randomized complete block design, RCBD, with three replications. Plot size was 6 by 15 feet. A CO_2-powered hand held sprayer equipped with four XR8006 VS tips was used to apply the treatments. Treatments were applied at 65 gallons/acre. Applications and ratings were made on May 31, 2000; September 22, 2000; and May 30, 2001. Applications made in May 2000 and 2001 were designated as "spring" treatments. "fall" treatments were those applied in September 2000. Ratings included Canada thistle counts, percent crownvetch cover, and average crownvetch height within each plot.

RESULTS AND DISCUSSION

The results of this study are confusing at best. In May, the site had an average of 39 stems per plot. By September 22, 2000, only 5 living Canada thistle stems were found across the entire study area. At this date the first flush of thistle had already dispersed seed and senesced.

Fall applications were made on September 22, 2000 despite the lack of Canada thistle within the test area. On May 31, 2001 a visit to the site revealed a continued lack of Canada thistle throughout the test. Crownvetch cover had also decreased for most of the plots but, still was acceptable, ranging from 55 to 82 percent, with no significant differences among treatments. At this stage the study was abandoned.

CONCLUSIONS

Previous work with these herbicides on Canada thistle has never provided the control experienced at this site. A possible scenario is that the repeated treatment of the Canada thistle was causing significant injury, but it was manifested in the reduction of the root system. The third year of treatment plus drought in 1999 may have stressed Canada thistle to the point of exhaustion of its reserves and left it very vulnerable to another treatment regimen plus the competition from the little-affected crownvetch.

We are still intent on evaluating a selective approach to managing Canada thistle in crownvetch. We will implement a future trial on a site without a treatment history, and use larger plots.

MANAGEMENT IMPLICATIONS

Though confounded, the results of this trial suggest that repeated treatments that do not seem to be affecting Canada thistle may be having a significant effect. We hope the Department will support the future evaluation of repeated application of selective treatments compared to a renovation approach.

Table 1. Canada thistle counts and percent crownvetch cover ratings taken May 31, 2000 and May 30, 2001. Treatments were made either "spring" (May 31, 2000 and May 20, 2001) and/or "fall" (September 22, 2000). Values are the mean of three replications.

Product/Timing	Spring Product Rate	Fall Product Rate	Canada thistle Count 5-31-00	Canada thistle Count 5-30-01	Crownvetch Cover 5-31-00	Crownvetch Cover 5-30-01
	(oz/ac)	(oz/ac)	(----------#----------)		(----------%----------)	
Untreated	----	----	21	5	96	73
Velpar-Spring	64		34	2	93	72
Velpar-Fall		64				
Plateau-Spring	12		54	1	72	82
Plateau-Fall		12	22	2	82	57
Plateau-Spring	6		44	0	63	68
Plateau-Fall		6				
Velpar-Spring	64		23	2	88	73
Plateau-Spring	12					
Velpar-Fall		64	69	23	72	55
Plateau-Fall		12				
Velpar-Spring	64		51	0	76	63
Plateau-Spring	6					
Velpar-Fall		64				
Plateau-Fall		6				
Velpar-Spring	64		37	0	83	65
Plateau-Spring	12					
Velpar-Fall		64				
Velpar-Spring	64		40	0	83	60
Velpar-Fall		64				
Plateau-Fall		12				
LSD (p=0.05)			n.s.	n.s.	n.s.	n.s.

EFFECT OF HERBICIDE AND APPLICATION TIMING ON CONTROL OF POISON HEMLOCK

Herbicide trade and common chemical names: Garlon 3A (*triclopyr*), Vanquish (*dicamba*), Velpar DF (*hexazinone*).
Plant common and scientific names: Poison hemlock (*Conium maculatum*), crownvetch (*Coronilla varia*).

ABSTRACT

The herbicide treatments Garlon 3A plus Vanquish at 24 plus 24 oz/ac, and Velpar DF at 21 oz/ac were applied to poison hemlock at the rosette, early bolt, and early bloom stages. Garlon 3A plus Vanquish provided 100 percent control at each timing. Injury to poison hemlock treated with Velpar DF was 47, 48, and 100 percent at rosette, early bolt, and early bloom stages, respectively.

INTRODUCTION

Poison hemlock is a biennial herb found throughout the southern half of PA. It continues to spread in extent and abundance, and due to its acute toxicity, poses a potential threat to humans and livestock wherever it occurs. Therefore control of this plant should receive high priority within the vegetation management program. This trial was initiated to evaluate the influence of application timing on the efficacy of two herbicide treatments, Garlon 3A plus Vanquish, and Velpar DF. Garlon 3A plus Vanquish could be used in a predominantly grass groundcover, while Velpar DF would be appropriate for groundcover that is primarily crownvetch.

MATERIALS AND METHODS

The trial was located in the border between a small grain field and a brush row in the PA State Game Lands 176, near State College, PA. The herbicide treatments were Garlon 3A plus Vanquish at 24 plus 24 oz/ac, and Velpar DF at 21 oz/ac. Each mixture included an organosilicone-based surfactant at 0.1 percent, v/v. Application dates were April 27, May 11, and June 4, 2001, which corresponded to rosette, early bolt, and early bloom growth stages of poison hemlock, respectively. Treatments were applied to 6 by 15 ft plots arranged in randomized complete block with three replications, using a CO_2-powered hand-held boom equipped with Spraying Systems XR8004VS tips, delivering 30 gal/ac at 20 psi. Percent control was rated on August 21, 2001.

RESULTS AND DISCUSSION

Untreated plants ranged from 3 to 7 ft tall, and had dropped 50 to 75 percent of their seed when rated. The Garlon 3A plus Vanquish combination provided 100 percent control at all three application timings. Control ratings for Velpar L were 47, 48, and 100 percent, for the rosette, early-bolt, and early bloom timings, respectively.

CONCLUSIONS

The mixture of Garlon 3A plus Vanquish was effective at all spring timings evaluated, and will probably be effective at any time poison hemlock is actively growing. Further investigation should evaluate the effectiveness of applications made in the fall after deciduous trees have dropped their leaves. There is a significant period of time available in this window, prior to growth cessation due to winter conditions, to manage herbaceous weeds.

The Velpar combination was only effective at the early bloom timing on June 4. Further evaluation will be needed to confirm this result, and evaluate other factors as well, such as carrier volume. A wider application window would be useful to facilitate managing the entire Velpar-sensitive weed spectrum in crownvetch. It would be particularly useful if poison hemlock could be controlled while it is still relatively short, prior to bloom.

MANAGEMENT IMPLICATIONS

Herbicide treatments have been identified for groundcovers dominated by grasses or crownvetch. Currently, effective poison hemlock management will require a spray vehicle capable of switching herbicide treatment based on groundcover. Poison hemlock treatment programs that do not preserve existing groundcover will only make the infestation worse. If the groundcover is eliminated poison hemlock will reinfest the site from the seedbank and a cycle of poison hemlock-bare ground-poison hemlock will be started.

Continued research on poison hemlock will need to include an emphasis on identifying herbicide treatments that can be used in either grass or crownvetch groundcovers.

COMPARISON OF GLYPHOSATE FORMULATIONS FOR THE CONTROL OF HERBACEOUS PERENNIALS

Herbicide trade and common chemical names: GlyPro (glyphosate, isopropylamine salt), Roundup Pro Dry (glyphosate, ammonium salt), Touchdown Pro (glyphosate, diammonium salt).

Plant common and scientific names: Canada thistle (*Cirsium arvense*), common pokeweed (*Phytolacca americana*), crownvetch (*Coronilla varia*), dandelion (*Taraxacum officinale*), plumeless thistle (*Carduus acanthoides*), quackgrass (*Elytrigia repens*), smooth brome (*Bromus inermis*), tall fescue (*Lolium arundinacea*), yellow foxtail (*Setaria lutescens*), yellow nutsedge (*Cyperus esculentus*), yellow woodsorrel (*Oxalis stricta*).

ABSTRACT

Two separate trials were conducted to compare perennial weed control provided by different glyphosate formulations. Touchdown Pro and Roundup Pro Dry were applied on May 30, 2001, to tall fescue at 1.5 and 3.0 lb acid equivalent/ac, at three carrier volumes. All treatments provided complete control. In a trial that compared Touchdown Pro and GlyPro, on a stand of crownvetch and mixed weeds, results were less clear-cut, and may have been confounded by rainfall shortly after application.

INTRODUCTION

Several manufacturers are now producing and marketing glyphosate products. The most familiar formulation contains the isopropylamine salt of glyphosate. Product examples of this formulation include Roundup, Roundup Pro, Accord, and Rodeo, as well as two products on the current state pesticide contract, GlyPro and DuPont Glyphosate. Glyphosate is currently available in two other formulations for the non-crop market, Roundup Pro Dry (ammonium salt) and Touchdown Pro (diammonium salt). Two trials were established to compare control provided by currently available formulations on herbaceous perennial species, and investigate the effect of carrier volume.

MATERIALS AND METHODS

The first trial was applied to an established stand of 'Kentucky 31' tall fescue at the Penn State Landscape Management Research Center, on May 30, 2001. Treatments were applied to 6 by 15 ft plots arranged in a randomized complete block design with a 2x2x3 factorial treatment arrangement and three replications. Touchdown Pro and Roundup Pro Dry were each applied at 1.5 and 3.0 lb acid equivalent (ae)/ac with a CO_2 powered, hand-held boom at 20, 40, and 60 gal/ac using Spraying Systems XR8002VS, XR8004VS, and XR8006VS tips, respectively. At the time of treatment, the tall fescue was in seedhead with leaf blades up to 14 inches tall and seedheads 24 inches in height. The site was initially a uniform stand of turf comprised of nearly 100 percent tall fescue with approximately 50 percent green cover ratings for all plots. Percent control was rated July 9, 40 days after treatment (DAT). Percent control and percent green cover were recorded on August 9 and September 5, 71 and 98 DAT.

The second trial was established in a stand of crownvetch at the Oak Hall interchange of SR 322, on August 16, 2001. Treatments were applied to 6 by 20 ft plots arranged in a randomized complete block with a 2x2x3 factorial treatment arrangement with three replications. Touchdown

Pro and GlyPro were each applied at 1.5 and 3.0 lb ae/ac with a CO_2 powered, hand-held boom at 20, 40, and 60 gal/ac using Spraying Systems XR8002VS, XR8004VS, and XR8006VS tips, respectively. QwikWet 357, an organosilicone surfactant, was added to all Glypro treatments at a rate of 0.125% v/v. A localized downpour occurred 80 min after completion of the application. Predominant species included crownvetch, tall fescue, quackgrass, plumeless thistle, and smooth brome. Initial percent green cover and crownvetch ratings were taken August 16, 0 days after treatment, DAT. Percent control was rated August 31 and September 25, 15 and 40 DAT, respectively.

RESULTS AND DISCUSSION

All rate and carrier volume combinations of Touchdown Pro and Roundup Pro Dry provided 100 percent control of the tall fescue in all treated plots at all three rating dates. Predominant weed species that appeared in plots at the September 5 rating included yellow woodsorrel, yellow nutsedge, yellow foxtail, common pokeweed, and dandelion. There were no significant differences in resulting weed cover, which ranged from 12 to 32 percent (data not shown).

The results from the crownvetch trial indicated interactions between glyphosate formulation and application rate (Table 1), and application rate and carrier volume (Table 2). Crownvetch control was nearly identical for Touchdown Pro and GlyPro at the 1.5 lb ae/ac rate at both 15 and 40 DAT. Control ratings for each formulation were significantly higher when applied at 3.0 lb ae/ac than for the 1.5 lb ae/ac rate. Control ratings for Touchdown Pro at the 3.0 lb ae/ac rate were significantly higher than those for GlyPro.

Carrier volume influenced control ratings at the 3.0 lb ae/ac rate, but not at the 1.5 lb ae/ac rate. At both 15 and 40 DAT, the 20 gal/ac rate was rated significantly higher for control than either the 40 or 60 gal/ac applications. The increase of glyphosate activity at lower carrier volumes has been reported in the weed science literature (Sandberg et al. 1978).

The control ratings on crownvetch were lower than anticipated (Table 3), and we wonder if the downpour that occurred 80 min after completion of the application is a possible cause for loss of efficacy. However, rainfastness trials with different glyphosate formulations have demonstrated that glyphosate at application rates of 6 lb ae/ac on brush species (Hipkins, 2002) and 2.88 lb ae/ac on Kentucky bluegrass (Taylorson, 2001) showed no improvement in control if simulated rainfall occurred more than 15 min after glyphosate application. Taylorson did note that symptoms appeared more quickly if irrigation occurred after 30 min of glyphosate exposure compared to 15 min of exposure before irrigation. The irrigation rates used in rainfastness studies may not be adequate to wash herbicide off the foliage. Rainfastness work reports total precipitation (0.1 to 0.2 inch), but not the intensity (in/hr). A downpour can have an intensity much greater than that of an irrigation system. Additionally, crownvetch is a very waxy-leaved plant, and conditions were dry at application and may have contributed to plant surface conditions that could inhibit rapid uptake of glyphosate. Prior to application, 0.99 in of rain had fallen in State College in August, 0.87 in one episode on August 11. In July, a total of 2.4 in of rain fell in State College[1].

The average crownvetch control ratings at 40 DAT for Touchdown Pro were higher than for GlyPro (59 and 49, respectively), and control ratings for the 3.0 lb ae/ac rate were significantly higher than for the 1.5 lb ae/ac rate, 67 and 40 percent, respectively.

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[1] Precipitation data from the PA State Climatologist, http://pasc.met.psu.edu/PA_Climatologist/cityform.html

CONCLUSIONS

Touchdown Pro and Roundup Pro Dry were completely effective on tall fescue at 1.5 and 3.0 lb ae/ac. Crownvetch control ratings were higher for Touchdown Pro compared to GlyPro, and Touchdown Pro treatments showed greater effect of reduced carrier volume and rate of application.

On a species level, we can demonstrate differences between glyphosate formulations. We do not have enough detailed observations across a broad spectrum of species to determine if glyphosate formulation efficacy will become an issue of consideration for vegetation managers.

MANAGEMENT IMPLICATIONS

We have enough information to know that there are many variables associated with the interaction of species, environmental conditions, and application rate and technique; and that we can show performance differences between glyphosate formulations. We cannot say whether a particular formulation of glyphosate will show itself to be consistently superior to other formulations. We believe that the glyphosate products on the current state pesticide contract will be effective, and formulation decisions in the near future will rely more on cost, availability, and product support issues than comparative efficacy.

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Table 1: Response of crownvetch treated August 16, 2001, showing the interaction of glyphosate formulation and application rate. Values are averaged over applications made in carrier volumes of 20, 40, and 60 gal/ac (n=9).

Products	Application Rate	Application Rate	Control Aug 31	Control Sep 25
	oz/ac	lb ae/ac	%	%
Touchdown Pro	64	1.5	20	39
Touchdown Pro	128	3.0	47	78
Glypro	48	1.5	20	41
Glypro	96	3.0	29	57
LSD(p=0.05)			9	10

Table 2: Response of crownvetch treated with glyphosate on August 16, 2001, showing the interaction of glyphosate application rate and carrier volume. Values shown are averaged over two glyphosate formulations (n=6).

Carrier Volume	Glyphosate Rate	Control Aug 31	Control Sep 25
gal/ac	lb ae/ac	%	%
20	1.5	21	39
40	1.5	19	37
60	1.5	20	44
20	3.0	53	79
40	3.0	30	62
60	3.0	31	61
LSD(p=0.05)		11	12

Table 3: Summary of crownvetch response to two glyphosate formulations applied at two rates and three carrier volumes on August 16, 2001. Each mean is the average of three replications.

Product	Application Rate	Carrier Volume	Control Aug 31	Control Sep 25
	lb ae/ac	gal/ac	%	%
Touchdown Pro	1.5	20	23	45
Touchdown Pro	1.5	40	20	35
Touchdown Pro	1.5	60	17	38
Touchdown Pro	3.0	20	68	90
Touchdown Pro	3.0	40	35	77
Touchdown Pro	3.0	60	37	67
GlyPro	1.5	20	18	33
GlyPro	1.5	40	18	38
GlyPro	1.5	60	23	50
GlyPro	3.0	20	37	68
GlyPro	3.0	40	25	47
GlyPro	3.0	60	25	55

COMPARISON OF GARLON 3A ALONE AND IN MIXTURES FOR THE CONTROL OF CROWNVETCH

Herbicide trade and common chemical names: Escort (*metsulfuron*), Garlon 3A (*triclopyr*), Hi-Dep (*2,4-D*), Transline (*clopyralid*), Vanquish (*dicamba*).
Plant common and scientific names: Canada thistle (*Cirsium arvense*), crownvetch (*Coronilla varia*), plumeless thistle (*Carduus acanthoides*), quackgrass (*Elytrigia repens*).

ABSTRACT

Garlon 3A was applied alone and in combination with Transline, Vanquish, Escort, or Hi-Dep to crownvetch. The control ratings for Garlon 3A alone at 32 oz/ac were 88 and 86 percent at 69 and 109 days after treatment, respectively, and were significantly lower than ratings for all other treatments. There were no significant differences between the control ratings for the other treatments, which ranged from 95 to 99 percent 109 days after treatment.

INTRODUCTION

The objective of this trial was to evaluate the efficacy of an experimental broadleaf herbicide in comparison with combinations of currently available products. The experimental material was evaluated under a secrecy agreement, and results for experimental materials will not be presented. Crownvetch was used as the target species due to its persistent, perennial nature, weedy characteristics, and availability in uniform stands. Although crownvetch exists primarily as a desirable, installed groundcover along PA roadsides, its presence in turf areas is not desirable, and data specific to controlling crownvetch is useful in a renovation context where thistle-infested crownvetch is to be replaced with a grass groundcover.

MATERIALS AND METHODS

The trial was initiated May 30, 2001, on the westbound shoulder of SR 322 near the Oak Hall interchange, outside of State College, Centre County. The treatments included an untreated check, a 'local standard' of Garlon 3A plus Escort at 48 plus 0.5 oz/ac, respectively; Garlon 3A at 32 or 64oz/ac alone; and Garlon 3A at 32 oz/ac in combination with either Transline at 5.3 oz/ac, Vanquish at 16 oz/ac, Escort at 0.15 oz/ac, or Hi-Dep at 32 oz/ac. All herbicide treatments included Arborchem Aquatic Surfactant at 0.25 percent, v/v. These treatments were applied to the middle 6 ft of 10 by 15 ft plots arranged in a randomized complete block design with three replications, using a CO_2-powered, hand held sprayer equipped with Spraying Systems XR 8004VS tips delivering 30 gal/ac at 30 psi. Average vegetative cover at the time of treatment ranged from 58 to 72 percent. The predominant species was crownvetch, which was 12 to 16 in tall, and ranged from vegetative to flower bud stage. Also present was quackgrass that was in the pre-boot stage, and Canada thistle that ranged from vegetative to flower bud stage, and a few stems of plumeless thistle. Visual ratings of broadleaf weed control, and cover provided by crownvetch, quackgrass, and Canada thistle on July 9, August 7, and September 8, 2001, or 40, 69, and 102 days after treatment (DAT). The data were subjected to analysis of variance, and means separated using Fisher's Protected LSD test. The untreated checks were not included in the analysis of variance because percent control was arbitrarily assigned a value of '0' in these plots.

RESULTS AND DISCUSSION

There were significant treatment effects at each rating date, despite seemingly small differences (Table 1). By August 9, 69 DAT, the 88 percent control rating for Garlon 3A alone at 32 oz/ac was significantly lower than for all other treatments, which ranged from 96 to 100 percent control. The situation was the same at 102 DAT, when Garlon 3A at 32 oz/ac was rated at 86 percent control, and the ratings for the other treatments ranged from 95 to 99 percent.

The effective control of crownvetch resulted in a reduction in vegetative cover (Table 2), and an increase in cover provided by quackgrass, which ranged from 4 to 10 percent in treated plots on July 9, and from 11 to 29 percent in treated plots on September 8 (Table 3). Canada thistle cover did not exceed 3 percent for any treatment throughout the study, and is not reported. In the untreated plots, crownvetch was the dominant component and quackgrass never provided more than 3 percent cover. Cover provided by crownvetch ranged from 52 to 62 percent on May 30. In the untreated plots crownvetch cover was 83, 72, and 85 percent at 40, 69, and 102 DAT, respectively. In treated plots, crownvetch cover ranged from 0 to 9 percent in the best-rated treatments, and 26 percent in the plots treated with Garlon 3A at 32 oz/ac. Cover and control are not entirely dependent on each other - the 86 percent control rating for Garlon 3A at 109 DAT does not mean there should be 14 percent cover. Control is a rating of biomass reduction, not lack of cover.

CONCLUSIONS

Garlon 3A at 32 oz/ac was the least effective treatment in the study. Crownvetch had initiated significant regrowth in these plots by 109 DAT. Increasing the Garlon 3A rate to 64 oz/ac, or combining Garlon 3A with either Transline, Vanquish, Escort, or 2,4-D provided significantly better control. The standard treatment, Garlon 3A plus Escort at 48 plus 0.5 oz/ac, respectively, was the best rated treatment 102 DAT, but control was not significantly different from the other combinations.

MANAGEMENT IMPLICATIONS

These results confirm the utility of the Garlon 3A plus Escort combination the Department relies on for weed and brush control. These results also serve as a useful demonstration of the value of mixtures of herbicides, as opposed to relying on a single ingredient.

Table 1. Summary of response of broadleaf species to herbicide treatments applied May 30, 2001. Control ratings were taken July 9, August 7, and September 8, 2001. The untreated checks were not included in the analysis of variance. Each value is the mean of three replications.

Product	Application Rate	----------------Broadleaf Weed Control --------------- July 9	August 7	September 8
	oz product/ac	%	%	%
untreated check		0	0	0
Garlon 3A	32	96	88	86
Garlon 3A	64	99	97	97
Garlon 3A Transline	32 5.3	97	98	98
Garlon 3A Vanquish	32 16	97	96	95
Garlon 3A Escort	32 0.15	96	96	95
Garlon 3A 2,4-D	32 32	99	98	97
Garlon 3A Escort	48 0.5	99	100	99
Fisher's Protected LSD (p=0.05)		2	5	7

Table 2. Summary of percent total vegetative cover in plots treated with herbicides on May 30, and evaluated on July 9, August 7, and September 8, 2001. The untreated checks were not included in the analysis of variance. Each value is the mean of three replications.

Product	Application Rate	Vegetative Cover May 30	July 9	August 7	September 8
	oz product/ac	%	%	%	%
untreated check		58	88	75	88
Garlon 3A	32	63	9	15	41
Garlon 3A	64	60	6	6	15
Garlon 3A Transline	32 5.3	67	7	10	22
Garlon 3A Vanquish	32 16	65	5	7	18
Garlon 3A Escort	32 0.15	72	11	19	38
Garlon 3A 2,4-D	32 32	58	8	15	34
Garlon 3A Escort	48 0.5	60	4	6	15
Fisher's Protected LSD (p=0.05)		ns	ns	ns	ns

Table 3. Response of cover provided by crownvetch (CZRVA) and quackgrass (AGRRE) to herbicide treatments applied May 30, 2001. Evaluations were made July 9, August 7, and September 8, 2001. Each value is the mean of three replications.

		Vegetative Cover						
	Application	May 30	Jul 9		Aug 7		Sep 8	
Product	Rate	CZRVA	CZRVA	AGRRE	CZRVA	AGRRE	CZRVA	AGRRE
	oz product/ac	%	%	%	%	%	%	%
untreated check		53	83	3	72	1	85	1
Garlon 3A	32	59	2	7	5	8	26	11
Garlon 3A	64	57	1	5	1	5	3	12
Garlon 3A Transline	32 5.3	59	1	6	1	9	3	19
Garlon 3A Vanquish	32 16	61	1	4	2	5	6	10
Garlon 3A Escort	32 0.15	62	1	10	2	17	9	29
Garlon 3A 2,4-D	32 32	52	0	8	1	14	5	26
Garlon 3A Escort	48 0.5	52	0	4	0	6	0	14

EVALUATION OF DERRINGER FOR BAREGROUND WEED CONTROL APPLICATIONS

Herbicide trade and common chemical names: Derringer (*glufosinate-ammonium*), DuPont Glyphosate (*glyphosate*), Oust (*sulfometuron*), Karmex (*diuron*).
Plant common and scientific names: annual fleabane (*Erigeron annuus*), buckhorn plantain (*Plantago lanceolata*), Canada thistle (*Cirsium arvense*), dandelion (*Taraxcum officinale*), giant foxtail (*Setaria faberi*), hemp dogbane (*Apocynum cannabinum*), Japanese brome (*Bromus japonicus*), orchardgrass (*Dactylis glomerata*), quackgrass (*Elytrigia repens*), sweet vernal grass (*Anthoxanthum odoratum*), yellow foxtail (*Setaria lutescens*).

ABSTRACT

Treatments containing Derringer or Glyphosate alone or in combination with Oust or Karmex were applied to a mixed-species stand of herbaceous vegetation on June 4, 2001, and rated for vegetative cover 33, 66, and 93 days after treatment (DAT). Plots treated with Derringer alone at 96 oz/ac were burned down within one week, but had significantly more vegetation than any other treatment by 33 DAT, and significantly higher cover than the untreated check by 66 DAT. At 66 DAT, only treatments containing Oust, or glyphosate plus Karmex were still effective. At 93 DAT, only glyphosate plus Oust was still having a significant effect on the reduction of vegetative cover.

INTRODUCTION

Herbicide applications to eliminate and prevent vegetation under guiderails, around signposts, and concrete islands are an integral part of managing roadside vegetation. The standard approach is to combine residual herbicides such as Oust and Karmex with a non-selective postemergence herbicide such as glyphosate. Glyphosate is a systemic herbicide, and though highly effective, the amount of time for symptom development is sometimes a concern for management not well acquainted with the product. Derringer is non-selective contact herbicide that provides quicker symptom development than glyphosate. Derringer does not control the below-ground parts of most perennial species, but will kill the top growth of almost all herbaceous vegetation. Combined with soil-active herbicides that would prevent regrowth of the top-killed vegetation, a Derringer treatment would provide quicker burndown and might provide residual control. However, the soil-active herbicides commonly used by PENNDOT, Oust and Karmex, are primarily active against weeds from seed rather than against established underground propagules. This study investigated the effectiveness of Derringer compared to Glyphosate, alone and in combination with Oust or Karmex, for providing non-selective, residual weed control.

MATERIALS AND METHODS

This trial was conducted at the Penn State Landscape Management Research Center, University Park, PA. The study was initiated on June 4, 2001. In addition to an untreated check, Derringer or Glyphosate were applied alone at 96 oz/ac each, and in combination with either Oust or Karmex at 3 or 96 oz/ac, respectively. Oust or Karmex were applied alone at 3 or 96 oz/ac, respectively, and Derringer was also applied at 128 or 160 oz/ac in combination with either Oust or Karmex at 3 or 96 oz/ac, respectively. All non-Derringer treatments included 0.1% v/v Qwikwet 357 organosilicone-blend surfactant.

Applications were made using a CO_2 powered backpack sprayer equipped with a hand-held boom and four XR 8006 VS tips. Operating pressure was 28 psi at the tank and carrier volume was 40 gal/ac. Plots were 6 by 15 feet arranged in a randomized complete block design, with three replications. Predominant species included Japanese brome, quackgrass, sweet vernalgrass, Canada thistle, and hemp dogbane. Plots were evaluated for percent green vegetative cover and species composition on June 4, July 7, August 9, and September 4, 2001; or 0, 33, 67, and 93 days after treatment (DAT), respectively.

RESULTS AND DISCUSSION

Initial cover ratings (0 DAT) ranged from 32 to 38 percent (Tables 1 and 2). Species were perennials such as quackgrass and orchardgrass, and an infestation of the winter annual Japanese brome.

At 33 DAT, the untreated plots had 58 percent cover, and the best-rated treatments had 1 percent cover. The only treatments with significantly higher cover than the best rated treatments were Derringer alone at 96 oz/ac (32 percent), Karmex alone at 96 oz/ac (17 percent), and Derringer plus Karmex, each at 96 oz/ac (20 percent). The Japanese brome had either been eliminated or senesced (untreated check), and the predominant vegetation was exclusively perennials (Table 3).

At 66 DAT, the untreated plots averaged 52 percent cover. Treatments containing Oust, and the Glyphosate plus Karmex treatment continued to provide the best reduction in vegetative cover with values from 10 to 19 percent. Glyphosate alone had largely eliminated the vegetation present at treatment, and these plots were now being colonized by yellow foxtail (Table 4). The Derringer plus Karmex treatments failed to kill the existing quackgrass and ended up working as a release treatment. At this date the plots treated with Derringer plus Oust showed no advantage compared to treating with Oust alone. The Derringer had provided quicker and more extensive burndown, but the effect was transient and the Derringer did not appear to enhance control of the perennial species present.

The only plots showing significant control at 93 DAT were those treated with Glyphosate plus Oust, which were rated at 26 percent cover. These plots had been mostly re-infested with hemp dogbane (70 percent cover in one plot), as the other two plots that were mostly Canada thistle had less than 5 percent cover. Hemp dogbane is a late-emerging perennial, and at the time of treatment, was not fully emerged. When treated, the hemp dogbane was only 'chemically mowed', while the other species in the plots treated with Glyphosate plus Oust were eliminated. No other treatment was significantly different than the untreated check, which had 92 percent cover. None of the Derringer combinations eliminated the perennial grasses that were originally present, and these species recovered and revegetated the plots (Table 5).

CONCLUSIONS

Derringer did not provide the control of perennial weeds that was observed with Glyphosate. Even when combined with Oust, Derringer treatments did not eliminate the perennial grasses present in the study. The lack of systemic activity is not adequately compensated for by the systemic activity of Oust, and especially not with the addition of Karmex. Derringer would only serve as a viable Glyphosate replacement where the treated vegetation is exclusively annual species that can be controlled by killing the top growth.

Glyphosate is still the most cost effective broad spectrum, non-selective, postemergence product for bareground weed control applications. Derringer, even at the highest rates used in this trial, did not provide the control observed using Glyphosate.

MANAGEMENT IMPLICATIONS

The only benefit of using Derringer compared to glyphosate is speed of symptom development, and this would be at the expense of weed control. There are very few situations where having symptoms develop a few days sooner provide a tangible benefit. If speed is truly desired, Derringer can be tank-mixed with glyphosate at reduced rates such as 16 oz/ac, which is 25 percent of the lowest label rate for Derringer. Previous work with the perennial grass Kentucky bluegrass (Poa pratensis) has shown this provides quick symptom development without the contact action of Derringer antagonizing the systemic activity of Glyphosate.

Table 1: Summary of green vegetative cover ratings following application of non-selective herbicides on June 4, 2001. Plots were evaluated on June 4, July 7, August 9, and September 4; 0, 33, 67, and 93 days after treatment (DAT), respectively. Each value is the mean of three replications.

Products	Application Rate	----------- Green Vegetative Cover (DAT) ---------- 0	33	66	93
	oz product/ac	(--------------------------	%	--------------------------	)
1. untreated	---	38	58	52	92
2. Derringer	96	33	32	80	97
3. Glyphosate	96	38	3	48	88
4. Derringer Oust	96 3	33	1	12	76
5. Derringer Oust	128 3	35	1	10	72
6. Derringer Oust	160 3	33	1	19	88
7. Glyphosate Oust	96 3	33	3	14	26
8. Derringer Karmex	96 96	35	20	67	98
9. Derringer Karmex	128 96	35	6	43	91
10. Derringer Karmex	160 96	32	7	60	95
11. Glyphosate Karmex	96 96	35	3	12	77
12. Oust	3	35	10	12	72
13. Karmex	96	33	17	53	84
LSD (p=0.05)		n.s.	10	26	26

Table 2. Percent cover and most common species present on June 4, 2001, the day of treatment. Cover values are the mean of three replications. Species represent the most common from each replication.

No.	Products	Application Rate (oz/ac)	Percent Cover	Predominant Species
1	untreated	- - -	38	tall fescue, orchardgrass, Japanese brome, quackgrass
2	Derringer	96	33	quackgrass, Japanese brome
3	Glyphosate	96	38	Japanese brome, quackgrass
4	Derringer + Oust	96 3	33	quackgrass
5	Derringer + Oust	128 3	35	quackgrass, Japanese brome
6	Derringer + Oust	160 3	33	quackgrass, Japanese brome, annual fleabane
7	Glyphosate + Oust	96 3	33	quackgrass, sweet vernalgrass, Japanese brome
8	Derringer + Karmex	96 96	35	quackgrass, Japanese brome
9	Derringer + Karmex	128 96	35	quackgrass, sweet vernalgrass, Japanese brome
10	Derringer + Karmex	160 96	32	orchardgrass, Japanese brome, quackgrass
11	Glyphosate + Karmex	96 96	35	tall fescue, orchardgrass, Japanese brome
12	Oust	3	35	orchardgrass, sweet vernalgrass, dandelion
13	Karmex	96	33	Japanese brome, orchardgrass

Table 3. Percent cover and most common species present on July 7, 2001, 33 days after treatment. Cover values are the mean of three replications. Species represent the most common from each replication.

No.	Products	Application Rate (oz/ac)	Percent Cover	Predominant Species
1	untreated	- - -	58	orchardgrass, quackgrass
2	Derringer	96	32	orchardgrass, hemp dogbane, Canada thistle
3	Glyphosate	96	3	dandelion, Canada thistle
4	Derringer + Oust	96 3	1	quackgrass, hemp dogbane, Canada thistle
5	Derringer + Oust	128 3	1	quackgrass, hemp dogbane
6	Derringer + Oust	160 3	1	quackgrass, Canada thistle,
7	Glyphosate + Oust	96 3	3	hemp dogbane
8	Derringer + Karmex	96 96	20	quackgrass, dandelion, Canada thistle
9	Derringer + Karmex	128 96	6	quackgrass, hemp dogbane, Canada thistle
10	Derringer + Karmex	160 96	7	hemp dogbane, Canada thistle
11	Glyphosate + Karmex	96 96	3	hemp dogbane, dandelion,
12	Oust	3	10	quackgrass, hemp dogbane,
13	Karmex	96	17	orchardgrass, Canada thistle, buckhorn plantain

Table 4. Percent cover and most common species present on August 9, 2001, 66 days after treatment. Cover values are the mean of three replications. Species represent the most common from each replication.

No.	Products	Application Rate (oz/ac)	Percent Cover	Predominant Species
1	untreated	- - -	52	quackgrass, orchardgrass
2	Derringer	96	80	orchardgrass, hemp dogbane, quackgrass
3	Glyphosate	96	48	yellow foxtail
4	Derringer + Oust	96 3	12	quackgrass, hemp dogbane, Canada thistle
5	Derringer + Oust	128 3	10	quackgrass, Canada thistle, hemp dogbane
6	Derringer + Oust	160 3	19	Canada thistle, quackgrass
7	Glyphosate + Oust	96 3	14	hemp dogbane, Canada thistle
8	Derringer + Karmex	96 96	67	quackgrass
9	Derringer + Karmex	128 96	43	quackgrass
10	Derringer + Karmex	160 96	60	quackgrass
11	Glyphosate + Karmex	96 96	12	Canada thistle, hemp dogbane, dandelion
12	Oust	3	12	hemp dogbane, Canada thistle
13	Karmex	96	53	quackgrass, orchardgrass, Canada thistle

Table 5. Percent cover and most common species present on September 4, 2001, 93 days after treatment. Cover values are the mean of three replications. Species represent the most common from each replication.

No.	Products	Application Rate (oz/ac)	Percent Cover	Predominant Species
1	untreated	- - -	92	orchardgrass, quackgrass
2	Derringer	96	97	quackgrass, hemp dogbane
3	Glyphosate	96	88	yellow foxtail
4	Derringer + Oust	96 3	76	quackgrass
5	Derringer + Oust	128 3	72	quackgrass, Canada thistle
6	Derringer + Oust	160 3	88	Canada thistle, quackgrass
7	Glyphosate + Oust	96 3	26	Canada thistle, hemp dogbane
8	Derringer + Karmex	96 96	98	quackgrass
9	Derringer + Karmex	128 96	91	quackgrass
10	Derringer + Karmex	160 96	95	quackgrass
11	Glyphosate + Karmex	96 96	77	quackgrass, Canada thistle, giant foxtail
12	Oust	3	72	quackgrass
13	Karmex	96	84	orchardgrass, Canada thistle, quackgrass

COMPARISON OF GLYPHOSATE FORMULATIONS FOR CONTROL OF PERENNIAL WEEDS

Herbicide trade and common chemical names: Endurance (*prodiamine*), Karmex (*diuron*), Oust (*sulfometuron*), Roundup Pro Dry (glyphosate, *ammonium salt*), Surflan (*oryzalin*), Touchdown Pro (*glyphosate*, *diammonium salt*).

Plant common and scientific names: annual fleabane (*Erigeron annuus*), Canada thistle (*Cirsium arvense*), dandelion (*Taraxacum officinale*), little bluestem (*Schizachyrium scoparium*), showy tick-trefoil (*Desmodium canadense*).

ABSTRACT

Two different glyphosate formulations, Roundup Pro Dry (ammonium salt) and Touchdown Pro (diammonium salt) were compared at two application rates for efficacy against herbaceous weeds, alone and in combination with Oust plus Karmex. There was no significant formulation effect observed during the trial, but plots treated with the higher glyphosate rate had less weed cover 46 days after treatment. The addition of Oust and Karmex to the glyphosate treatments improved and extended overall weed control, but did not impact Canada thistle control. The addition of Endurance or Surflan to Touchdown Pro changed the spectrum of species that were present, but did not significantly improve the weed control provided by Touchdown Pro alone.

INTRODUCTION

There has been a proliferation of glyphosate products on the market, both in the number of trade names available for the familiar isopropylamine formulation (i.e. Roundup) as well as new formulations. This trial was conducted at the request of Syngenta to evaluate perennial weed control provided by Touchdown Pro, a new glyphosate formulation containing the diammonium salt. The product for comparison was Roundup Pro Dry, which is the ammonium salt of glyphosate. The glyphosate products were tested alone and in combination with various preemergence herbicides on a mixed stand of herbaceous weeds that included a moderate to severe infestation of Canada thistle.

MATERIALS AND METHODS

The trial was established at the Penn State Landscape Management Research Center on May 23, 2001. Treatments were applied to 6 by 20 ft plots, arranged in a randomized complete block with three replications, using a CO_2-powered backpack sprayer equipped with a 6 ft boom and Spraying Systems 8004 VS tips, delivering 40 gal/ac at 28 psi. Treatments included an untreated check; and a sequence of treatments including each glyphosate formulation at 1.5 lb or 3.0 lb ae/ac. These acid equivalent rates correspond to Touchdown Pro at 64 or 128 oz/ac, respectively, and Roundup Pro Dry at 36 or 72 oz/ac, respectively. The two products were applied at the two rates alone or in combination with 3 oz/ac Oust plus 128 oz/ac Karmex. Additionally, Touchdown Pro was applied at 64 or 128 oz/ac in combination with 37 oz/ac Endurance or 64 oz/ac Surflan. No adjuvants were added because both glyphosate products are surfactant-loaded. Predominant species in the test area included Canada thistle, little bluestem, showy tick-trefoil, dandelion, and annual fleabane. Initial percent green cover, a Canada thistle stem count, and a species inventory were taken May 25, 2 days after treatment (DAT), prior to symptom onset. Visual assessments of percent green vegetative cover were taken July 7 and August 9, 45 and 78 days after treatment (DAT), respectively. A count of surviving Canada thistle stems and a visual assessment of Canada thistle percent-of-stand were taken on July 7 and August 9, respectively. Both surviving Canada thistle and resprouts were again counted on September 6, 106 DAT, to determine the percent control of treated stems and percent resprouting. The data were subjected to analysis of variance, and single degree-of-freedom contrasts evaluating the effect of glyphosate formulation and glyphosate rate were conducted.

RESULTS AND DISCUSSION

The initial green cover ratings taken 2 DAT ranged from 62 to 77 percent, and were not significantly different. On July 7 all treated Canada thistle stems were dead, but resprouting had begun in the treated plots. There was no difference in the weed control provided by the two formulations of glyphosate at any of the rating dates. Glyphosate rate was a significant effect on weed cover at 45 DAT. Though the Oust plus Karmex added to the glyphosate treatments extended the length of control of most of the weeds, they did not prevent the resprouting of Canada thistle in September. The addition of Endurance or Surflan to the Touchdown Pro did not significantly improve the weed control provided by comparable treatments, but the species spectrum was changed. Dandelion was the most common species in plots not treated with Oust plus Karmex. Where Endurance or Surflan were included in the treatment, dandelion co-existed with residual perennials such as showty ticktrefoil, big bluestem, little bluestem, Indiangrass, and switchgrass. In plots treated with glyphosate alone, annual grasses such as giant foxtail and yellow foxtail, and common ragweed were also common. Showy ticktrefoil appeared to be tolerant of all treatment combinations, and was the most common species in the plots treated with Oust plus Karmex.

CONCLUSIONS

There were no differences in control found between Touchdown Pro and Roundup Pro Dry when used at equivalent rates. Resulting vegetation after treatment was affected primarily by tank mix herbicides.

MANAGEMENT IMPLICATIONS

Glyphosate product selection is determined by the state pesticide contract. The challenge posed by competing glyphosate products, that to date have been equally efficacious, will likely be in developing specifications that provide the Department an opportunity to obtain the most economic product, regardless of its formulation.

Table 1: Summary of vegetative response to non-selective herbicide applications made May 23, 2001 to a mixed stand of herbaceous species. Each value is the mean of three replications.

Products	Application Rate	Jul 7 Vegetative Cover	----------Aug 9---------- Vegetative Cover	Canada Thistle Cover	Sep 6 Canada Thistle Resprouting
	oz/ac	%	%	%	%
1. untreated	- - -	65	65	20	88
2. Touchdown Pro	64	16	53	4	35
3. Touchdown Pro	128	13	65	4	42
4. Roundup Pro Dry	36	18	72	5	16
5. Roundup Pro Dry	72	9	50	7	61
6. Touchdown Pro Oust Karmex	64 3 128	1	3	1	49
7. Touchdown Pro Oust Karmex	128 3 128	1	3	2	72
8. Roundup Pro Dry Oust Karmex	36 3 128	1	3	3	67
9. Roundup Pro Dry Oust Karmex	72 3 128	1	7	5	111
10. Touchdown Pro Endurance	64 37	13	32	9	113
11. Touchdown Pro Endurance	128 37	4	45	6	68
12. Touchdown Pro Surflan	64 64	14	60	15	73
13. Touchdown Pro Surflan	128 64	5	42	10	74
LSD (p=0.05)		10	27	n.s.	n.s.

COMPARISON OF WEED CONTROL PROVIDED BY MILESTONE VM AND OTHER RESIDUAL HERBICIDES ON AN INDUSTRIAL SITE

Herbicide trade and common chemical names: Milestone VM (*azafeniden*), Glyphosate (*glyphosate*), Krovar I DF (*bromacil + diuron*), Oust (*sulfometuron*), Velpar DF (*hexazinone*).
Plant common and scientific names: sand dropseed (*Sporobolus cryptandrus*), bearded sprangletop (*Leptochloa fascicularis*)

ABSTRACT

On an industrial site infested primarily with sand dropseed, herbicide treatments that included Milestone VM, Krovar I, Oust, or Velpar were rated at 93 percent control or better. Glyphosate alone was rated at 33 percent control. Weed pressure on the site was sparse with limited species.

INTRODUCTION

Milestone VM has been evaluated by this project on several occasions dating back to the 1995 season. In the first few trials it was known by experimental number R-6447. This herbicide has shown promise as a tank mix partner with several other products for bareground application. Due to its ounces-per-acre use rates, it is slated as an alternative to Karmex, which is used at 6 to 8 lbs per acre.

Bearded sprangletop is a troublesome summer annual grass species that has become a particular nuisance in industrial sites and guiderail areas throughout southeastern Pennsylvania. This summer annual grass reportedly escapes many of the common mixes used for these bareground situations. Bearded sprangletop thrives in wet sites and alkaline soils[1/], and often appears in areas on industrial sites where puddling occurs. Plants grow from 12 to 40 inches. They can develop large monocultures in areas where they exist.

Although the locale for this trial had sufficient sprangletop pressure, it turned out the study site itself did not have sufficient amounts of bearded sprangletop to justify rating control for this species. Sand dropseed, a warm-season perennial grass, classified as 'Rare' by the PA Biologic Survey in 1997, was present in quantities high enough to establish efficacy ratings for this species. Though uncommon in PA, sand dropseed is a common weed in other parts of the US.

MATERIALS AND METHODS

This study was established at an industrial site in Eddystone, PA, Delaware County on April 26, 2001. Thirteen herbicide treatments were applied, including a rate sequence of 4 to 10 oz/ac of Milestone VM alone and in combination with Krovar I, Krovar I alone, Oust plus Krovar, and Velpar. All residual treatments included Glyphosate at 64 oz/ac, and Glyphosate was also applied alone (Table 1). All treatments included Qwikwet 357, surfactant, at 0.1% v/v. The study was arranged in a randomized complete block design, with three replications. Treatments were applied using a CO_2-powered backpack sprayer equipped with a hand-held boom using 8002 VS tips, calibrated to spray 30 gallons/acre. Plot size was 3 by 25 feet.

1/ http://www.ipm.ucdavis.edu/PMG/WEEDS/bearded_sprangletop.html

Evaluations were made May 31, July 6, August 3, and September 5, 2001; 1, 2, 3, and 4 months after treatment, MAT, respectively. Due to the absence of vegetation, numerical ratings were not taken on May 31. Ratings taken 2 MAT included percent control compared to the untreated check while those taken at 3 and 4 MAT included both overall percent control and percent sand dropseed.

RESULTS AND DISCUSSION

On April 26, 2001, at the initiation of the study, there were only a couple of scattered plants present across the entire site. Even on May 31, 1 MAT, there were too few plants to evaluate the study. By July 6, only 2 to 4 percent vegetative cover was established in the untreated checks. Sand dropseed accounted for most of the cover present during this rating. All treatments, except glyphosate alone, ranged from 93 to 100 percent control when compared with the untreated plots while glyphosate provided 63 percent control. These trends continued in the two months that followed. Control was still 93 to 100 percent for all treatments except glyphosate alone by September 5, 2001. Glyphosate control had dwindled to 33 percent by this date. This would be expected with no preemergence herbicide added to prevent seeds from germinating in those plots. Vegetative cover in the untreated checks only ranged from 5 to 20 percent by the final rating on September 5th. Sand dropseed comprised 65 to 100 percent of the vegetative cover in these untreated checks. Although sand dropseed was the most prevalent species it was not found in every plot so a statistical analysis was not done for this species.

CONCLUSIONS

All residual treatments were effective against the sparse weed pressure on the site. Unfortunately, the information-to-effort ratio for this trial was fairly low due to the lack of vegetation.

MANAGEMENT IMPLICATIONS

Just prior to publication of this report, DuPont reported that they would no longer be pursuing registration of Milestone VM. This is unfortunate as azafeniden was a new active ingredient with a mode of action unique to this market. Previous work by our project, as well as Experimental Use Permit applications in several Engineering Districts had demonstrated the preemergence utility of Milestone VM against a broad spectrum of species, plus postemergence activity on a narrower range of species. It would have provided an easy to use, low-rate material that would have provided an herbicide rotation option in addition to its useful species spectrum.

Table 1: Weed control provided by herbicide treatments applied April 26, 2001. Ratings of percent control, compared to the untreated check, were taken July 6, August 3, and September 5, 2001. The untreated check plots were not included in the analysis of variance. Each value is the mean of three replications.

Product	Application Rate	Weed Control Jul 6	Weed Control Aug 3	Weed Control Sep 5
		%	%	%
Untreated	---	0	0	0
Glyphosate	64	63	33	33
Milestone VM Glyphosate	4 64	97	97	93
Milestone VM Glyphosate	6 64	100	97	93
Milestone VM Glyphosate	8 64	100	100	100
Milestone VM Glyphosate	10 64	98	100	98
Krovar I DF Glyphosate	128 64	100	100	100
Milestone VM Krovar I DF Glyphosate	4 128 64	93	95	97
Milestone VM Krovar I DF Glyphosate	6 128 64	100	100	100
Milestone VM Krovar I DF Glyphosate	8 128 64	100	100	100
Milestone VM Krovar I DF Glyphosate	10 128 64	100	100	100
Milestone VM Glyphosate	20 64	100	100	100
Oust Krovar I DF Glyphosate	3 128 64	93	98	97
Velpar DF Glyphosate	64 64	100	100	100
LSD (p=0.05)		n.s.	28	28

HERBICIDE SCREENING TRIAL FOR CONTROL OF KOCHIA

Herbicide trade and common chemical names: 2,4-D Amine (*2,4-D*), Accord (*glyphosate*), Arsenal (*imazapyr*), Endurance (*prodiamine*), Escort (*metsulfuron*), Garlon 3A (*triclopyr*), Milestone VM (*azafenidin*), Karmex (*diuron*), Krovar I DF (*bromacil + diuron*), Oust (*sulfometuron*), Pendulum (*pendimethalin*), Plateau (*imazapic*), Pursuit (*imazethapyr*), Simazine 4L (*simazine*), Spike 80W (*tebuthiuron*), Surflan (*oryzalin*), Telar (*chlorsulfuron*), Tordon K (*picloram*), Transline (*clopyralid*), Vanquish (*dicamba*), Velpar DF (*hexazinone*), Vista (*fluroxypyr*).
Plant common and scientific names: kochia (*Kochia scoparia*).

ABSTRACT

Several herbicides were tested for their activity against kochia in a greenhouse setting. Biotypes of kochia have been documented to be resistant to several herbicide modes of action. Of twelve herbicides that were tested for preemergence activity, only Oust, Endurance, and Pendulum were rated as ineffective. Only four of eleven postemergence products, Escort, Vanquish, Vista, or Velpar DF, provided acceptable postemergence control, with control ratings ranging from 82 to 99 percent. The biotype of kochia evaluated was susceptible to herbicides currently used in PENNDOT's bareground program.

INTRODUCTION

Kochia is a summer annual weed that is found throughout most of the lower 48 states. It is a common weed in the western US, where it thrives in almost any disturbed setting, from row crops to roadsides. Kochia has been documented to have biotypes resistant to atrazine, Banvel, Escort, Oust, Telar, and Pursuit. Without making a systematic survey, we have observed kochia in Districts 2, 4, 5, 8, and 12. The population we observed in District 5 in 1999 was in an herbicide trial, and was resistant to Oust. In 2000, District 12 reported areas of kochia along the fringe of treatment areas along guiderails treated with Oust, Karmex and Velpar.

To determine whether the District 12 infestation was an issue of resistance, a greenhouse study was developed to screen a wide range of herbicides available to PENNDOT, using seed collected by Mike Maurer, Roadside Specialist, District 12-0, in October 2000.

MATERIALS AND METHODS

Collected kochia seed was screened to remove inert matter, tested for germination, and found to be viable. Four-inch pots filled with soilless media were seeded at a rate of 0.25 teaspoon seed per pot on February 15, 2001, lightly covered with more medium, and then watered lightly to wet the mixture without floating the seed. Preemergence herbicide treatments were applied on February 15, 2001 using a CO_2-powered sprayer equipped with a single 8003E tip, applying 40 gal/ac at 30 psi. Five pots were used for each treatment. The five pots were sprayed at one time outside, watered, then arranged on the greenhouse bench in a randomized complete block with five replications, where each pot was a replicate. The pots were watered as needed. Greenhouse temperatures fluctuated throughout the study and ranged from 48 to 86 degrees F. Six grams of Osmocote 18-18-18 fertilizer was applied to each pot on February 26, 2001.

Postemergence herbicide treatments were applied using the same application method on March 23, 2001, 36 days after seeding. The pots were left outside for one hour following spraying, misted to remove as much herbicide as practical from the pots and soil surface to limit potential volatilization, and then returned to the greenhouse. All postemergence treatments included 0.1% v/v Freeway surfactant.

An insecticide, Merit 75 WP, was applied to the plants on April 11, 2001 to control an outbreak of aphids on the plant foliage. Kochia control was rated on May 1, 2001, by visually assessing the percent biomass reduction compared to the check for each replication. Each check pot was assigned a value of zero, therefore the analysis of variance excluded the checks.

RESULTS AND DISCUSSION

By February 20, 2001 germination was evident in every treatment. The largest seedlings were 0.6 inches in height. On May 1, Preemergence applications of Karmex, Milestone VM, Krovar I, Spike, and Velpar provided 100 percent control. Simazine, Arsenal, Surflan, and Plateau were rated at 99, 94, 94, and 93 percent control, respectively. The ratings for Pendulum and Oust were 80 and 71 percent control, respectively, which were significantly lower that the best rated treatments (Table 1). Only Endurance, rated at 24 percent control, was completely ineffective.

The postemergence treatments fell into three activity groups. The most effective treatments were Vanquish, Velpar, Escort, and Vista, which were rated at 99, 94, 82, and 82 percent control, respectively. These ratings were not significantly different from each other. There was statistically significant reduction in activity with Arsenal (lower rate than preemergence), Accord, Garlon 3A, and 2,4-D; which were rated at 50, 34, 34, and 34 percent control, respectively. Telar, Tordon K, and Transline were completely ineffectual, and were rated at 6, 4, and 4 percent control, respectively.

The sulfonlyurea herbicides Oust, Escort, and Telar, and the imidazolinone herbicides Arsenal, Plateau, and Pursuit have the same mode of action, and are referred to as acetolactase synthase (ALS) inhibitors, and inhibit the synthesis of branched-chain amino acids, which are essential to growth. These herbicides all affect the same binding site of the acetolactase synthase enzyme. The kochia biotype we tested was highly resistant to postemergence applications of Telar, and moderately resistant to preemergence applications of Oust. This same biotype was susceptible to postemergence application of Escort, and to preemergence applications of Arsenal and Plateau. The 16 oz/ac rate of Arsenal applied postemergence was also active on kochia, though less than the 48 oz/ac rate applied preemergence.

All of the herbicides in this trial that are photosystem II inhibitors - Simazine, Velpar, and Karmex, Spike, and Krovar I - were effective. The growth regulator type herbicides were widely divergent in their activity. Vanquish was highly active, and the ratings for Vista were not significantly different from those for Vanquish. Garlon 3A and 2,4-D showed moderate activity, but did not provide acceptable control. Activity on kochia from Tordon K or Transline was barely detectable. Glyphosate, in the form of Accord, showed activity, but was ineffective. Milestone VM was completely effective, but is not coming to market, and will not be an option.

CONCLUSIONS

The population of kochia sampled in this study showed resistance to Telar and Oust. The roadside-labeled herbicides Arsenal, Karmex, Krovar I, Spike, Surflan, Vanquish, and Velpar were highly effective against kochia. This biotype of kochia is not a 'superweed' that will escape currently used herbicide mixes.

MANAGEMENT IMPLICATIONS

The kochia examined to date is susceptible to herbicides commonly used by PENNDOT, notably Karmex, which is almost universal in its adoption by the Department. However, due to its inherent abilities to thrive in bareground settings, kochia will increase in this state and most likely become as ubiquitous as species such as common ragweed and giant foxtail.

Where guiderail areas are treated in alternate years and not addressed by the weed and brush program in the intervening year, kochia will thrive and spread.

Oust, Karmex, and glyphosate comprise the basic mix most often used to control weeds under guiderails in Pennsylvania. Two of the three products in this mix have demonstrated inadequate levels of control against kochia. If these herbicides are applied after kochia has already germinated the Karmex may lack the postemergence activity to properly control this plant. This study demonstrates that mixes need to be adjusted and alternated from year to year. This will help prevent a buildup of resistant kochia in Pennsylvania as seen in other western states.

Table 1: Control of kochia provided by pre- and postemergence herbicide applications. Preemergence applications were made February 15, and and postemergence applications were made March 23, 2001. Ratings for percent control were taken May 1, 2001. Each value is the mean of five replications. The untreated check was not included in the analysis of variance.

Product	Application Timing	Application Rate	Control May 1
		oz product/ac	%
untreated check	- - -	- - -	0
Oust	PRE	3	71
Arsenal	PRE	48	94
Karmex	PRE	128	100
Plateau	PRE	12	93
Milestone VM	PRE	10	100
Endurance	PRE	24	24
Surflan	PRE	96	94
Pendulum	PRE	155	80
Krovar I	PRE	160	100
Spike 80W	PRE	64	100
Velpar DF	PRE	43	100
Simazine 4L	PRE	64	99
2,4-D amine	POST	34	34
Telar	POST	1	6
Escort	POST	1	82
Vanquish	POST	24	99
Garlon 3A	POST	32	34
Vista	POST	16	82
Transline	POST	16	4
Tordon K	POST	32	4
Arsenal	POST	16	50
Velpar DF	POST	21	94
Accord	POST	64	34
LSD (p=0.05)			19

CONTROL OF THE PERENNIAL GRASS SAND DROPSEED WITH BAREGROUND HERBICIDE TREATMENTS

Herbicide trade and common chemical names: Arsenal (*imazapyr*), Glyphosate (*glyphosate*), Endurance (*prodiamine*), Hyvar X (*bromacil*), Karmex (*diuron*), Oust (*sulfometuron*), Pendulum (*pendimethalin*), Plateau (*imazapic*), Sahara (*imazapyr + diuron*), Spike 80W (*tebuthiuron*), and Surflan (*oryzalin*).
Plant common and scientific names: bearded sprangletop (*Leptochloa fascicularis*), sand dropseed (*Sporobolus cryptandrus*).

ABSTRACT

On an industrial site with light weed pressure, where the most common species was sand dropseed, all treatments with a residual component provided effective control. On September 5, 2001, 132 days after treatment, the untreated check plots averaged 25 percent cover.

Sand dropseed was classified as 'Rare' in PA by the Pennsylvania Biologic Survey as recently as 1997, but its prevalance on industrial sites in SE PA may cause a change in that status.

INTRODUCTION

This study was intended to evaluate a host of preemergence materials for the control of bearded sprangletop. Bearded sprangletop has become a nuisance weed in many industrial and guiderail sites throughout southeastern Pennsylvania. This summer annual grass reportedly escapes many of the common herbicide mixes used for these bareground situations. Bearded sprangletop thrives in wet sites and alkaline soils[1/], and often appears in areas on industrial sites where puddling occurs. Plants grow from 12 to 40 inches. They can develop large monocultures in areas where they exist.

The objective of this trial was to screen a wide range of soil-active herbicides used for industrial weed control.

Although the property used for this trial had sufficient sprangletop pressure, it turns out the actual study site did not have sufficient amounts of bearded sprangletop to justify rating control for this species. Sand dropseed, a warm-season perennial grass, classified as 'Rare' by the PA Biologic Survey in 1997, was present in quantities high enough to establish efficacy ratings for this species. Though uncommon in PA, sand dropseed is a common weed in other parts of the US.

MATERIALS AND METHODS

This study was established at an industrial site on fill material in Eddystone, Delaware County, PA. On April 26, 2001 sixteen treatments were applied using Hyvar X, Karmex, Endurance, Arsenal, Pendulum, Sahara, Spike 80W, Surflan, Plateau, or Oust. All treatments included 64 oz/ac Glyphosate to control existing vegetation, plus 0.1% v/v Qwikwet 357 surfactant. Untreated check and Glyphosate alone plots were also established to provide references for how much each preemergence product contributed to the control. Refer to Table 1 for specific rates of the herbicides mentioned. The study was arranged in a randomized complete block design with three replications. Treatments were applied using a CO_2-powered backpack

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[1/] http://www.ipm.ucdavis.edu/PMG/WEEDS/bearded_sprangletop.html sprayer equipped with a hand-held boom and four 8004 VS tips, calibrated to spray 50 gallons/acre. Plot size was 6 by 15 feet.

Evaluations were made May 31, July 6, August 3, and September 5, 2001, roughly 1, 2, 3, and 4 months after treatment, MAT, respectively. Due to the absence of vegetation, numerical ratings were not taken on May 31. Ratings taken 2 MAT included percent control compared to the untreated check, while those taken at 3 and 4 MAT included both percent control and percent of vegetation that was sand dropseed.

RESULTS AND DISCUSSION

On April 26, 2001, at the initiation of the study, there were only a couple of scattered plants present across the entire site. Even on May 31, 1 MAT, there were too few plants to evaluate the study. By July 6, only 1 to 5 percent vegetative cover was established in the untreated checks. Sand dropseed accounted for most of the cover present during this rating. Treatments ranged from 50 to 97 percent control when compared with the untreated plots. However, 50 to 97 percent control of a 5 percent cover is very little vegetation. By August 3 control had increased for nearly all treatments, except glyphosate alone. Glyphosate control had dwindled to 20 percent by this date. This would be expected with no preemergence herbicide added to prevent seeds from germinating in those plots. Vegetative cover in the check plots averaged 25 percent by the final rating on September 5th (data not shown). Sand dropseed comprised 83 to 100 percent of the vegetative cover in the study. The plots treated with Glyphosate only were indistinguishable from the untreated plots. The only resdidual treatment rated significanly lower for control than the best rated treatment was Endurance plus Glyphosate at 37 plus 64 oz/ac, respectively. Plots treated with Endurance at 25 oz/ac were rated signficantly higher for control than the 37 oz/ac rate. This points out the difficulties of trying to determine control on a site with sparse, inconsistent weed pressure.

There were scattered plants of bearded sprangletop in the study area, but these were selectively grazed by geese back to the crown, so no reliable evaluation of herbicide effect could be made.

CONCLUSIONS

Weed pressure on the test site was quite low, and each of the herbicide products applied was effective at controlling sand dropseed. No useful information about bearded sprangletop was collected.

MANAGEMENT IMPLICATIONS

The preemergence herbicides tested in this trial will provide adequate control of sand dropseed. Endurance is the only questionable product on the list of those compared. This trial evaluated solitary residual products to determine the vulnerability of sprangeltop to each active ingredient. In practice, a bareground program would rely on a mixture of residual herbicides because individual active ingredients will not be effective against each of the many species encountered along bareground settings.

Table 1: Ratings of percent control, compared to the untreated check, for herbicide treatments applied April 26, 2001. Ratings were taken July 6, August 3, and September 5, 2001. Each value is the mean of three replications. Vegetative cover in the untreated plots averaged 25 percent.

Product	Application Rate	Control July 6	Control August 3	Control September 5
	(oz/ac)	%	%	%
Untreated	---	0	0	0
Glyphosate	64	50	20	0
Hyvar X Glyphosate	80 64	97	100	98
Hyvar X Glyphosate	160 64	97	99	97
Karmex Glyphosate	240 64	63	92	90
Endurance Glyphosate	25 64	57	90	89
Endurance Glyphosate	37 64	52	70	73
Arsenal Glyphosate	64 64	80	96	94
Pendulum Glyphosate	154 64	50	86	92
Sahara Glyphosate	200 64	88	90	93
Spike 80W Glyphosate	64 64	65	84	93
Spike 80W Glyphosate	80 64	80	91	89
Surflan Glyphosate	128 64	89	95	93
Plateau Glyphosate	12 64	63	87	90
Oust Glyphosate	3 64	96	91	86
Oust Glyphosate	6 64	81	92	94
Protected LSD (p=0.05)		n.s.	22	14

EVALUATION OF AN EXPERIMENTAL IMAZAPIC:GLYPHOSATE PREMIX HERBICIDE FOR BAREGROUND WEED CONTROL

Herbicide trade and common chemical names: Roundup, Rodeo, or DuPont Glyphosate (*glyphosate*), Plateau (*imazapic*), Oust (*sulfometuron*), Karmex (*diuron*).

Plant common and scientific names: annual dropseed (*Sporobolus vaginiflorus*), bearded sprangletop (*Leptochloa fascicularis*), birdsfoot trefoil (*Lotus corniculatus*), chicory (*Cichorium intybus*), common ragweed (*Ambrosia artemisiifolia*), crownvetch (*Coronilla varia*), giant foxtail (*Setaria faberi*), orchardgrass (*Dactylis glomerata*), purpletop (*Tridens flava*), sand dropseed (*Sporobolus cryptandrus*), smooth brome (*Bromus inermis*), spotted knapweed (*Centaurea maculosa*), switchgrass (*Panicum virgatum*), tall fescue (*Lolium arundinacea*), white sweetclover (*Melilotus alba*), wild carrot (*Daucus carota*), wild parsnip (*Pastinaca sativa*)

ABSTRACT

A premix of imazapic plus glyphosate was evaluated in a bareground setting and compared to glyphosate alone, combinations of the premix with Oust and Karmex, and a standard treatment of glyphosate, Oust, and Karmex. On an industrial site with low weed pressure all treatments with a residual component were equally effective. On a guiderail site with higher weed pressure, the premix alone was more effective than glyphosate alone, but less effective than the standard treatment. Plant cover ratings for combinations of the premix with Oust, Karmex, or all three, were not significantly different from those of the standard.

INTRODUCTION

BASF has recently developed a premix containing 0.75 lb/gal imazapic plus 1.5 lb ae/gal glyphosate. Imazapic is the ingredient of the herbicide Plateau. We have evaluated the utility of Plateau for bareground applications in both trials[2,3/] and field day demonstrations. The objective of this trial was to evaluate the utility of this premix, which includes a seemingly low glyphosate concentration. At an application rate of 32 oz/ac, the premix provides the maximum label rate of imazapic, equivalent to 12 oz/ac of Plateau, and the equivalent of 16 oz/ac of a typical glyphosate herbicide (or 0.38 lb glyphosate acid), such as Roundup or DuPont Glyphosate. The most commonly used glyphosate rate for guiderail applications is 64 oz/ac (1.5 lb glyphosate acid).

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[2] Evaluation Of Plateau For Total Vegetation Control Under Guiderails, Twelfth Annual Research Report.

[3 /] Evaluation Of Plateau And Sahara For Total Vegetation Control Under Guiderails, Thirteenth Annual Research Report.

MATERIALS AND METHODS

This trial was conducted at two sites, an industrial complex in Eddystone, Delaware County, and a guiderail site in State College, Centre County.

Eddystone Trial

Nine herbicide treatments and an untreated check were applied to an area of industrial fill material on April 26, 2001. The herbicide treatments included DuPont Glyphosate alone at 16 or 64 oz/ac; the premix of imazapic and glyphosate (premix) at 32 oz/ac, alone and in combination with 128 oz/ac Karmex; premix at 16 oz/ac plus Oust at 1 oz/ac, with or without Karmex at 128 oz/ac; a 'standard' treatment of Oust plus Karmex plus Glyphosate at 2 plus 128 plus 64 oz/ac, respectively; Oust at 1 oz/ac; and Karmex at 128 oz/ac. All herbicide treatments included a methylated seed oil surfactant[4] at 32 oz/ac. The study was arranged as a randomized complete block design, with three replications. Plot size was 6 by 20 feet. Treatments were applied using a CO_2-powered, hand-held boom equipped with Spraying Systems XR8004 VS tips, calibrated to spray 30 gallons/ac. The primary species of interest at the site was bearded sprangletop. The most common species at the time of treatment was sand dropseed, both established and seedling. Weed control evaluations were made May 31, July 6, August 3, and September 5, 2001. Due to lack of weed pressure (drought), no numerical data was collected on May 31. Data were subjected analysis of variance, and where treatment effect was significant, means were compared using Fisher's Protected LSD (p=0.05).

State College Trial

The second site was located along a guiderail on westbound SR 3007. This study included the herbicide treatments applied at Eddystone, minus the Oust- or Karmex-alone treatments. The glyphosate formulation used was Rodeo, which contains 4 lbs of glyphosate acid per gallon compared to the 3 lb/gallon of DuPont glyphosate. The product application rates were reduced to provide the same glyphosate dosage. Preemergence treatments were sprayed on April 12, and the early postemergence treatments were applied May 17, 2001. Plots were 4 by 25 ft, arranged in a randomized complete block with a two by 10 factorial treatment arrangement, and 3 replications. Treatments were applied using a CO_2-powered, hand-held sprayer with a single Spraying Systems OC-06 tip, calibrated to spray 30 gal/ac. Treatments applied April 12, 2001 were rated for percent green vegetative cover on April 12, May 17, July 8, August 9, and September 5, 2001 (0, 35, 87, 119 and 146 days after treatment, DAT, respectively). Early postemergence treatments applied on May 17, 2001 were rated for percent green cover on May 17, July 8, August 9, and September 5, 2001 (0, 52, 84, and 111 DAT, respectively). The most common species were spotted knotweed and wild parsnip. Other species included orchardgrass, wild carrot, white sweetclover, chicory, common ragweed, giant foxtail, smooth brome, and dandelion.

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[4] Sun-It II, 100% methylated seed oil, American Cyanamid Company, Wayne, NJ.

RESULTS AND DISCUSSION

Eddystone Trial

The anticipated infestation of bearded sprangletop did not develop. The few plants that were present were selectively grazed by geese. Percent vegetative cover in the untreated check plots was 5, 12, and 25 percent on July 6, August 3, and September 5, respectively. Sand dropseed accounted for 95 to 100 percent of the cover. On September 5, ratings for Glyphosate at 16 or 64 oz/ac was rated at 58 and 66 percent control, respectively. All other treatments, which included preemergence herbicides, were rated between 90 and 99 percent control.

State College Trial

Untreated vegetative cover ranged from 9 to 18 percent on April 12, and 22 to 30 percent on May 17. Cover in the untreated checks was rated at 65, 57, and 79 percent on July 6, August 9, and September 5, respectively (Table 2).

On May 17, the Rodeo treatments applied April 12 had cover ratings of 13 and 12 percent. The vegetation was primarily wild parsnip and spotted knapweed that had not been killed, rather than newly emerging weeds. The highest rated treatment was Rodeo plus Oust plus Karmex, at 1 percent cover. The primary species in these plots was also wild parsnip and spotted knapweed, though many of the plants were still showing significant injury, primarily chlorosis.

When the data for both application dates was analyzed together for the July 6, August 9, and September 5 ratings, the effect of treatment was significant at all three dates. The effect of application date was only significant for the July 6 rating. On this date, the preemergence treatments averaged 35 percent cover, and the postemergence treatments averaged 21 percent cover. There was no interaction between herbicide treatment and application date at any rating, therefore the results for the July 6, August 9, and September 5 ratings are reported as the mean of the April 12 and May 17 application dates (Table 2).

The standard treatment of Rodeo plus Oust plus Karmex was never rated higher than 2 percent cover at any post-treatment rating date. Cover in plots treated with Rodeo-only were rated significantly higher than the standard at each rating date, and there was no difference in cover ratings between the Rodeo rates. The only residual herbicide treatment with significantly higher cover ratings than the standard was the premix alone, and only on September 5. The addition of Oust or Karmex, alone or together to the premix, did not provide a significant decrease in groundcover. Cover in plots treated with the premix alone was significantly lower than in plots treated with the low rate of Rodeo, which was the same glyphosate dosage as in the premix.

CONCLUSIONS

The premix alone was not as effective as the Oust-Karmex-glyphosate standard, but when the premix was combined with Oust or Karmex the results were not significantly different from the standard. Despite a glyphosate dosage that is below common application rates, there was enough postemergence activity in the premix when combined with Oust or Karmex to provide performance similar to the standard treatment.

MANAGEMENT IMPLICATIONS

The premix is experimental and may never be marketed. This trial does point out the contribution to postemergence activity provided to a glyphosate mixture by imazapic, Oust, or Karmex. The counter is that although the commonly used 1.5 lb ae/ac rate of glyphosate may not be needed on the spectrum of species evaluated in these two trials, glyphosate is increasingly inexpensive, and currently used rates provide a form of cheap insurance. The species evaluated in these trials begin active growth early in the season. In locations where later-growing perennials such as the warm-season grasses purpletop and switchgrass are present, higher glyphosate rates would be needed.

Table 1: Control provided by treatments applied to an industrial site in Eddystone, PA on April 26, 2001. All treatments included a methylated seed oil surfactant at 32 oz/ac. Control ratings were taken July 6, August 3, and September 5, 2001. Each value is the mean of three replications. The untreated check was not included in the analysis of variance.

Treatment	Application Rate	Control Jul 6	Control Aug 3	Control Sep 5
	(oz/ac)	%	%	%
untreated	---	0	0	0
Glyphosate	16	73	85	58
Glyphosate	64	82	76	66
premix	32	71	96	92
premix Karmex	32 128	98	98	98
premix Oust	16 1	80	97	97
premix Oust Karmex	16 1 128	92	97	94
Glyphosate Oust Karmex	64 2 128	98	100	99
Oust	1	96	96	90
Karmex	128	83	99	98
LSD (p=0.05)		n.s.	n.s.	23

Table 2: Vegetative response to herbicide treatments at the Park Avenue guiderail site. Applications were made April 12 or May 17, 2001. The May 17 data is for the April 12 application only (n=3), and the July 8, August 9, and September 5 data is the average of the April 12 and May 17 application dates (n=6). The untreated check was not included in the analysis of variance.

	Application	---Vegetative Cover---			
Product	Rate	May 17	Jul 8	Aug 9	Sep 5
	oz product/ac	%	%	%	%
untreated	---	27	65	57	79
Rodeo	12	13	36	35	53
Rodeo	48	12	35	31	53
premix	32	4	14	19	26
premix Karmex	32 128	8	10	9	15
premix Oust	16 1	4	10	11	15
premix Oust Karmex	16 1 128	3	9	6	10
Rodeo Oust Karmex	48 2 128	1	2	1	2
LSD (p=0.05)		10	14	15	20

EVALUATION OF COMPANION SPECIES USED IN THE ESTABLISHMENT OF A NATIVE GRASS-BASED SEED MIX ON ROAD CONSTRUCTION SPOIL

Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), big bluestem (*Andropogon gerardii*), blackeyed Susan (*Rudbeckia hirta*), Canada wildrye (*Elymus canadensis*), crownvetch (*Coronilla varia*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), perennial ryegrass (*Lolium perenne*), redtop (*Agrostis gigantea*), roundheaded bushclover (*Lespedeza capitata*), showy ticktrefoil (*Desmodium canadense*), spring oats (*Avena sativa*), switchgrass (*Panicum virgatum*), and tall fescue (*Festuca arundinacea*).

ABSTRACT

This test compared several grass species for use as companions in seed mixes for roadside groundcover plantings. A seeding of a native grass and forb mix along with each of six companion seed mixes was made on August 2, 2000. It was apparent from evaluations made on April 30, 2001 that poor establishment resulted with all species. The most important factor appeared to be the lack of mulch. Areas immediately adjacent to the site were seeded the same week as the study was established. Straw mulch was applied to these areas and annual ryegrass and crownvetch was successfully established. The test area seedbed was only tracked-in with a bulldozer following a broadcast seeding. No mulch was applied based on suggestions from others involved in reclamation using warm-season grasses. Based on the establishment success of the area immediately adjacent to our study, which was seeded at the same time, we feel the elimination of mulch during seeding was a mistake. Future work needs to include mulch at the time of seeding. The native seed mix will have to be able to tolerate and overcome the competition imposed by any temporary components that become established.

INTRODUCTION

Revegetating disturbed soils and spoil after roadway construction is not simply a matter of finding a plant material that will grow on the site to satisfy erosion and sedimentation control requirements. Several environmental resource agencies have an interest in the final form of the right-of-way, so considerations of habitat value have significant impact on the plant community that is selected for establishment. Additionally, the term 'invasive species' is becoming commonplace in the conservation lexicon, and exotic species with a long track record of use such as crownvetch are receiving considerable scrutiny. The growth characteristics that allow crownvetch to persist and thrive on highly disturbed sites also allow it thrive in settings where it is not desirable. The Federal Highway Administration (FHWA) has included crownvetch on a short list of species regarded as weedy[5], and the USDA Natural Resource Conservation Service (formerly Soil Conservation Service), a former champion of crownvetch, describes it as weedy and overused[6]. However, since there are no invasive species or Noxious Weed lists with regulatory status, either federal or state, that include crownvetch, there are currently no legal means to exclude its use.

We are evaluating a seed mixture based around the perennial grasses big bluestem, little bluestem, Indiangrass, Canada wildrye, and switchgrass. These grasses are adapted to sub-

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[5] *In* Roadside Use of Native Plants, at http://www.fhwa.dot.gov/environment/rdsduse/rdsduse4.htm
[6] Plant Fact Sheet: Crownvetch. 2002. USDA-NRCS. Available at http://plants.usda.gov/

optimal site conditions, provide habitat value, and are native to our region. In addition, they are in the trade, have a use history, and are supported by public and private sector expertise. Our aim is to develop a seed mix and associated establishment requirements that would provide a viable alternative to seeding Formula C, the Department's primary slope-seeding mixture. Formula C is annual ryegrass plus crownvetch at 24.2 plus 19.4 lb/ac, respectively.

One problem associated with these native grass species is their slow stand establishment. This is a factor of both the establishment rate of the individual plants and the relatively low seeding rates that anticipate eventual plant populations. These grasses mature into large plants. At their mature size an approximate stand density of one plant/ft^2, or slightly less, is desired. Prior to these plants maturing, the soil must be covered and stabilized by other plants. In a crownvetch seeding this is accomplished using annual ryegrass, which will provide cover, then residue for a long enough period to provide temporary cover until the crownvetch is well enough established. Our experiences to date suggests that native grass mixtures will require companion species that will provide a longer term cover than annual ryegrass.

This study investigates the use of annual and perennial species as companions for a native grass seed mix. We relied on the advice of reclamation specialists who favored an approach directed towards the individual establishment of the native grasses in the shorter-term, rather than that of the stand. Therefore we relied on relatively low seeding rates of the companion species. We also opted not to use the standard straw mulch treatment, but relied instead on tracking the slope after seeding with a bulldozer. Tracking provides seed incorporation through a cultipacker effect from the track cleats, and the formation of 'mini-terraces' from the tracks that are perpendicular to the slope.

MATERIALS AND METHODS

This trial was located at the newly created interchange of SR 220/SR 322 in State College, on an east facing fill area with a 50 percent slope. The substrate was limestone spoil with an applied clay layer, about 2 in thick, applied with a bulldozer. A soil test taken for the clay material indicated a pH of 7.4, low organic matter (1.3 percent), and excessive calcium (72 percent CEC saturation). The permanent seed mixture was big bluestem, little bluestem, Indiangrass, each at 5 lb pure live seed (PLS)/ac; switchgrass at 1 lb PLS/ac, and showy ticktrefoil, roundheaded bushclover, and blackeyed Susan, at, 1, 1, and 0.5 lbs/ac respectively. The companion species treatments were annual ryegrass at 20 lb/ac, perennial ryegrass at 20 lb/ac, 'Kentucky 31' tall fescue at 20 lb/ac, redtop at 1 lb/ac, Canada wildrye at 10 PLS/ac plus annual ryegrass at 10 lb/ac, and spring oats at 30 lb/ac. Plot width was 10 ft, but slope length increased, so plots ranged from 1030 to 1690 ft^2. The study was laid out in a randomized complete block design, with three replications.

The permanent and companion mixes were seeded separately, by hand, to each plot, on August 2, 2000. Two hours following completion of the seeding the slope was tracked using a D6 bulldozer moving up and down the slope. The tracking served to incorporate the seed into the soil, and the track cleats left furrows perpendicular to the slope that served as 'mini-terraces' to slow surface water movement and improve infiltration. No soil amendments were added to the site.

On April 30, 2001 a rating was made to determine the percent cover by the companion species. The data was subjected to analysis of variance, and means were tested using Fisher's Protected LSD.

On May 19, 2001 the entire study site was overseeded to annual ryegrass to provide vegetative cover in the bare areas. Straw was applied by hand following this seeding.

RESULTS AND DISCUSSION

The rating taken on April 20, 2001 revealed that the temporary, companion seedings provided average cover values that ranged from 1 to 20 percent (Table 1). Permanent species cover was less than 1 percent, and the most common species was blackeyed Susan. Throughout the trial area plants of little bluestem were discovered that had perished over the winter, apparently due to frost heaving.

The level of establishment by the best performing cover crops was still unacceptable. The areas surrounding the study were seeded to Formula C by the site contractor within two days of this trial being established, using specified amendments and straw mulch. This conventional seeding was much more successful than those in the trial area.

There were areas of erosion channels, though these were caused by the berm at the top of the slope being breached, causing flow concentration at the very top of the slope.

CONCLUSIONS

This study relied too heavily on establishment recommendations generated by specialists working in other fields of reclamation. We also seeded quite late in the window for warm-season grasses. However, we needed to make do with the situation provided, and gathering data points on the seeding window for a native grass-based seed mixture is necessary.

Based on the successful establishment of annual ryegrass and crownvetch in the immediately adjancent areas of the same slope, using straw mulch as specified in Publication 408, we feel that tracking is not a suitable alternative to mulching. Further investigations may be pursued to see if tracking in the seed prior to mulching aids establishment. The lack of mulch impacted the establishment of the companion species, and in combination with the seeding date may have drastically reduced establishment of the permanent seed mixture.

MANAGEMENT IMPLICATIONS

There is increasing pressure to replace crownvetch in seed mixtures. However, we are currently not aware of viable alternatives to revegetate the types of sites currently being created by roadway construction. Most likely, if crownvetch use is going to be phased out, it will require changes in construction practices, and considerable effort in developing a multi-component seed mix and associated establishment practices.

Table 1: Percent cover provided by companion species or mixtures seeded with a mixture of big bluestem, little bluestem, Indiangrass, switchgrass, roundheaded bushclover, showy ticktrefoil, and blackeyed Susan. Each value is the mean of three replications.

Product	Seeding Rate	Cover April 30, 2001
	(lb/ac)	%
Annual Ryegrass	20	16
Perennial Ryegrass	20	15
K-31 Tall Fescue	20	14
Redtop	1	1
Canada Wildrye Annual Ryegrass	10 PLS 10	20
Spring Oats	30	9
LSD (p=0.05)		10

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Herbicide trade and common chemical names: Garlon 3A (triclopyr amine) Garlon 4 (triclopyr ester), Karmex (*diuron*), Oust (*sulfometuron*), Plateau (imazapic), Vanquish (dicamba), Velpar (hexazinone).

Plant common and scientific names: tree-of-heaven, or ailanthus (*Ailanthus altissima*), annual ryegrass (*Lolium multiflorum*), big bluestem (*Andropogon gerardii*), birdsfoot trefoil (*Lotus corniculata*), Canada thistle (*Cirsium arvense*), Canada wildrye (*Elymus canadensis*), creeping red fescue (*Festuca rubra* ssp. *rubra*), crownvetch (*Coronilla varia*), deertongue (*Panicum clandestinum*), giant foxtail (*Setaria faberi*), hairy wildrye (*Elymus villosus*), hard fescue (*Festuca brevipila*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), London planetree (*Platanus occidentalis*), mile-a-minute (*Polygonum perfoliatum*), pin oak (*Quercus palustris*), plumeless thistle (*Carduus acanthoides*), poison hemlock (*Conium maculatum*), purpletop (*Tridens flava*), scarlet oak (*Quercus coccinea*), showy ticktrefoil (*Desmodium canadense*), tall fescue (*Lolium arundinacea*), Tartarian honeysuckle (*Lonicera tatarica*), weeping lovegrass (*Eragrostis curvula*).

Interchange Ailanthus Removal and Beautification

The northeast quadrant of the SR 26/University Drive interchange is the site of an effort to convert an ailanthus infestation to a 'beautified' interchange featuring native woody and herbaceous species.

The ailanthus was cut and stump-treated by District 2-0 contract forces during January 2000. In March, 2000, Penn State Project personnel removed woody debris from the site, consolidated wood chip piles, and broadcast little bluestem at 5 lb PLS/ac after the soil surface was loosened using the teeth of a skid-steer bucket. The intent of the seeding was try to get the little bluestem established prior to the crownvetch regrowth developing a full canopy, then treating the crownvetch with selective herbicides to leave the young grasses. The crownvetch was treated May 24, using Garlon 4, Vanquish, and Plateau at 24, 8, and 4 oz/ac, respectively, applied at 5 gal/ac using Thinvert. The crownvetch control was good, but this establishment attempt saw only limited success, and is not an approach we would recommend. The existing undesirable vegetation should be eliminated prior to seeding warm season grasses when a uniform stand is desired. This operation is an example of the problems to be experienced when trying to replace an existing stand of crownvetch. Existing crownvetch is a difficult to control perennial plant, and older stands have a tremendous seed bank. We anticipated difficulty with the crownvetch, and this is why there are no forbs in the seeding mixtures. Forbs introduced in the future will be established plants placed in clusters.

The ailanthus resprouts and crownvetch were treated June 16, 2000, using a mix of Garlon 4, Vanquish, and SilWet L-77 at 64 oz/ac, 16 oz/ac, and 0.1% v/v, respectively; with a targeted application rate of 15 gal/acre using backpack sprayers. Ailanthus sprouts were treated, and the native trees and shrubs were planted in September, 2000, by students in Penn State's Landscape Contracting major, as part of a class project. All woody plantings were mulched with black plastic with a layer of wood chips on top.

On May 9, 2001, broadleaved weeds were spot treated with a mixture of Garlon 3A plus Vanquish at 4 plus 1 percent, v/v, using backpack sprayers. The site was disked twice and seeded to a mix of little bluestem, big bluestem, Indiangrass, deertongue, purpletop, Canada wildrye, and hairy wildrye, at 16 lb PLS/acre, on May 22, 2001. Bank areas were seeded to a mix of hard fescue, creeping red fescue, and annual ryegrass (Formula L - 55, 35, and 10 percent, by weight, respectively) at 100 lb/acre. The results of the May 9 application were disappointing, and retreatment was necessary. On July 11, the areas planted to the native grasses were treated with Garlon 3A plus Vanquish at 32 plus 8 oz/acre, respectively.

In the week prior to the field day, the taller weeds in the tree and shrub area, primarily plumeless thistle and Canada thistle, were cut using motorized trimmers. Herbicide application was limited in close proximity to the small trees to limit injury, particularly since the weeds were fairly tall. Trying to spray tall weeds around small trees with broadleaf herbicides is a recipe for disaster, and there were instances from the May application where herbicide injury symptoms were noticeable on the foliage of the young trees.

The planting is not at a stage yet where it is 'ornamental'. The native grasses are not well established, and the trees are small. The ailanthus is still resprouting, but has been held in check. None of the elements employed will provide instant impact. It was understood from the outset that with the resources that were available, it would be several years before the plan would have a visual impact.

Crownvetch as a Weed in Formula L Conversions

We viewed a site (from the bus) on SR 322 at the end of the Mt Nittany Expressway that looked like an old crownvetch planting with Canada thistle in it. It was. It was also an area that had been converted from crownvetch/Canada thistle to Formula L in the fall of 1993, and seen during the field day in 1994. In the intervening period, the successful conversion was overrun by crownvetch, and has returned to its original thistle-infested state, with almost no trace of the fine fescue to be found.

It's like the game rock-paper-scissors. Canada thistle beats crownvetch, crownvetch beats Formula L, and Formula L beats Canada thistle. You have to choose the weed you want to manage in this situation. Is it easier to manage crownvetch as a weed in your grass, or Canada thistle as a weed in your crownvetch?

We feel that managing dicots (broadleaf weeds) in grass is somewhat easier than managing thistle in crownvetch. Some of this is agronomic, and some of this is institutional.

You can mow grass when you have weeds in it. There is an institutional bias against mowing crownvetch, but you can do it.

Herbicide selection for use in crownvetch is largely limited to Velpar and Plateau. Velpar effectively topkills Canada thistle in crownvetch, and if used persistently over several seasons should eventually eliminate most of the thistle. Velpar also has a fairly broad species spectrum, and will control biennial thistles and poison hemlock, annuals such as mile-a-minute, and will at least defoliate most brush. Plateau will top-kill thistle in crownvetch in the spring, and should be even more effective in the fall. Our use has been limited to one late-October evaluation and that wasn't effective. The advantage of a grass groundcover is that there are several systemic herbicides available that will provide control of Canada thistle, other broadleaved weeds, and brush and not injure the turf. These herbicides are more effective than Velpar because they translocate to the root system, and cause greater injury to the thistle.

Selective Thistle Management in Crownvetch, Revisited

Canada thistle management in crownvetch was one of the primary objectives of the research project at its initiation in 1985. After several years of investigation, we decided that Velpar seemed to be the best selective tool, but that it was not good enough - it would have to be applied annually. Our efforts transitioned to replacing the crownvetch/thistle complex with Formula L, whereupon we discovered that the Formula L would require nearly annual maintenance to prevent crownvetch from re-establishing from it's seemingly endless seedbank. Crownvetch grows above the low-growing fine fescues and smothers them. Once the crownvetch is re-established, thistle can become reestablished (see previous stop). This then puts the question of approach into these terms - which weed do you want to manage? Do you want to manage thistle in crownvetch, or crownvetch in Formula L? Neither would be the preferred option, but once thistle appears in crownvetch, the 'neither' option only works until somebody calls the Department of Agriculture about your thistle garden. Then you have to choose.

This stop demonstrated selective herbicide options and the effect of mowing on Canada thistle seed production.

The herbicide plots were Velpar DF at 21 oz/acre, Plateau at 12 oz/acre, or the combination of Velpar DF and Plateau at 21 plus 12 oz/acre, respectively. These three plots were applied at 80 gal/acre, on June 7, 2001. The fourth herbicide plot was Velpar DF at 21 oz/acre in Thinvert, applied at 5 gal/acre on June 8, 2001.

The mowing treatment was initiated on June 8, 2001, when the Canada thistle was still in bud stage. This area was mowed with a rotary mower set at a five-inch cutting height.

All four herbicide treatments provided encouraging results. The Velpar at 80 gal/ac plot had some Tartarian honeysuckle, which was treated and largely defoliated. The Velpar/Thinvert plot was a mixed stand of crownvetch and grass, and showed the phytotoxicity of Velpar to grasses. The top-kill of Canada thistle and control of the biennial plumeless thistle was very good.

The mowing treatment greatly reduced flowering of the thistle, and showed no apparent detriment to the crownvetch. It was shorter than the adjacent unmowed plot, but had regrown vigorously. Based on this area, on observations relayed from District 3-0, as well as flowering behavior of other perennials, there is a definite optimum timing to mow Canada thistle to prevent flowering and seed set. Our timing was a little early to completely prevent flowering, but was effective. Our guess is that there is a two to three week window in which mowing will effectively reduce seed set, ranging from early bud to late bloom stage. Plants mowed early in the window will send up new shoots and some will flower. At the late bloom stage, many plants may already have ripened seed. Mowing will effectively prevent further maturation of the seed, but most likely will not damage intact flower heads, which will probably still open after they've been cut.

There is enough crownvetch in mowable terrain in thistle-plagued areas of the state that inclusion of these areas in the mowing program should be implemented as a regular practice.

SR 6026 Landscaping Installation Issues

Kevin Hoover, Inspector-in-Charge, provided an overview of the scope of this segment of the I-99 construction. The CO5 segment is due for completion in October 2001. This segment runs from the new bridges spanning SR 144, to the interchange with the Bellefonte Bypass (SR 26).

Several issues were addressed as tour participants walked among several of the plantings. Clearly, we understand that many of the difficulties associated with landscape development on construction projects are due to the very minor role that the landscaping plays in eight-to-nine figure construction projects. Clearly, the inspection expertise on a project has to be oriented towards the elements contributing directly to the integrity of the roadway.
This, however, does not excuse us from identifying inadequacies and trying to devise means to address them within the current scheme of things, as well as trying to develop a better scheme to

accomplish quality landscape implementations within the scope of huge highway construction projects.

Planting Design

Two issues come to mind here - planting location and layout of the planting.

This project demonstrated both desirable and undesirable locations. Taking advantage of open space at interchanges, in areas where drivers have an opportunity to safely glance at the landscape is a desirable feature. Undesirable locations tended to be planting salt-sensitive white pine too close to the roadway, and attempts to 'soften' bridge structures. These structure-softening plantings were in locations that were not easily viewed by motorists, either because of obscurement due to landscape location, or because the planting were in locations where drivers should not be looking away from the road. In addition to this, some of the plantings were placed so that they would be extensively shaded by the bridge. It is not practical to try to soften the appearance of a 1000 foot long bridge with shrub beds and several shade trees, even large-growing species such as London planetree. This bridge exists on a visual scale that cannot be impacted by ornamental plantings.

Put plantings where they can be seen and enjoyed, at a safe distance from the travel lanes.

The second issue is planting layout, specifically spacing. In general, plantings feature too much space between trees. The reasons for this are several, but they are arguably immaterial. There is no good reason to isolate trees in a beautification planting because there are too many benefits to clustered plantings, including:

- preventing death-by-maintenance, when mowers run between, and into trees
- enhanced aesthetic impact - more of a focal point
- planting in beds with shared rooting space free of competing vegetation promotes more vigorous growth
- ease of maintenance - it's easier to maintain one large bed than multiple tree circles
- ease of establishment - it's easier to prepare and improve the soil in a large bed than many planting holes.

Let's review situations where non-optimal plantings have resulted.

Literal translation of construction plans - we hear of situations in which tree placement is done to precisely match plant placement as shown on construction diagrams, regardless of quality of the site after earth moving. This is not a good practice. Planting designs are put on the plan before earth has been moved. Planting designs are not properly scaled because the circles indicating individual trees are too big (they anticipate mature size on good sites), and we are told that they cannot overlap in the CAD layout. Planting locations and layouts on highway construction plans must be regarded as *suggested*. If inspectors are going to literally interpret plans (particularly in Districts where the expertise of the Roadside Specialist is not utilized in construction projects), then a different method of drafting needs to be employed. Rather than placing circles for each and every plant on the map, simply indicate the approximate planting location, a square footage for the planting bed preparation (see below), and a list of plants. This provides all the detail needed for bid specifications, but allows for an adaptive plant layout to be employed.

Lack of site preparation - adoption of clustered plantings should also then entail implementation of Shrub Bed Preparation as described in Section 808.3(c) of Publication 408. Prior to incorporation of organic material or compost, the planting area should be loosened. Common landscape-quality, tractor-mounted rototillers may not be rugged enough to loosen construction site soils sufficiently. Our experience on this project site indicated that a grader-mounted ripper/scarifier is ideal,. After loosening with the scarifier, and removal of the large rocks, a rototiller could be used to incorporate the soil amendments. After bed preparation, there would be no need for planting-hole amendments. Additionally, the holes could be dug very quickly in the loosened, prepared soil; compared to the effort of trying to dig a series of holes in disturbed, compacted, and destroyed soils.

Tree/Shrub Species Selection

This will always be a source of disagreement because there are many philosophies of planting design. However, following a few basic principles will prevent many planting failures.

Salt sensitivity - there are only a few species that are highly salt-sensitive, but white pine is one of them. Keep white pines out of the corridor where salt spray will be prevalent.

Alkaline-induced iron deficiency - pin oak and scarlet oak are susceptible to this. After construction, much of the soil on site is limestone-derived subsoil, or limestone spoil. Planting bottomland species on dry, high pH sites is a recipe for failure.

Post-construction soils tend to be shallower, more compact, and have less organic matter than the soils present prior to construction. Tree and shrub species selection should focus on plants adapted naturally to drier, low-quality sites, regardless of what might be considered an appropriate plant for a locality *prior* to construction.

Plant Material Inspection

There were instances on-site where trees were tagged with incorrect species names, or incorrect cultivar names. These tags were generic, handwritten tags, and suggested premeditated misidentification. Plant material should have tags from the nursery with the nursery's name and location. In addition, the Department should implement a more intensive inspection, either by using a specialist-inspector when the plants arrive on site, or actually mark the plants in the nursery with a numbered tag system that would allow tracking of each plant. A checklist scheme could be developed that any diligent inspector, regardless of horticultural training, could use on site.

Plants need to be inspected for both aboveground and belowground quality. Simply relying on the one year guarantee will not suffice. Low quality plants can survive the required one year on site. These plants rarely become vigorous plants. It is important to be able to locate the root flare at the base of the trunk. As we saw on the construction site, with both pin oaks and London planetree, it is possible for viable plants to show up on site with their original root flare being buried nine inches deep. Such trees have even less of their root system than a properly cultured ball-and-burlap tree, and are much more likely to come to an untimely end, *after* the guarantee period.

On-site inspection needs to be made with trunk wrap removed, to prevent obscurement of stem defects.

Seed Mixes for Slopes

This construction project featured no use of Formula C (crownvetch, annual ryegrass). There are arguments for not using crownvetch, such as its weediness, or the superior soil-binding of perennial warm season grasses. However, there are currently no alternatives to Formula C in Publication 408 for highly disturbed sites. Seeding formulas D (tall fescue, creeping red fescue), L, or W (tall fescue, birdsfoot trefoil) are not adapted to the poor site conditions typical to cut and fill slopes, particularly fill slopes consisting primarily of limestone spoil. These seedings will provide less cover than would be achieved with Formula C, and may simply fail to establish.

We have established two trials on one of the fill slopes on the project to evaluate a warm-season grass-based mixture. This mixture (we refer to this as Formula A) contains big bluestem, little bluestem, Indiangrass, Canada wildrye, and showy ticktrefoil.

One trial is a comparison of Formula A and Formula C. The other trial is a comparison of Formula A with and without switchgrass. Switchgrass is the most vigorous of the grasses we are considering for reclamation seedings, but we have concerns about its weediness in the future. Where present along highways, it seems to readily colonize behind guiderails. As long as it is behind the guiderail, this is fine. However, should switchgrass or any other perennial warm season grass become established in front of the guiderail it would be problematic.

These trials were seeded in May 2001. They will be viewed during the 2004 Field Day.

We are investigating alternative mixtures to Formula C because we feel a warm-season grass mix has advantages over crownvetch. Warm-season grasses are more tolerant of drought and low pH than crownvetch. Grasses bind soil together better than crownvetch, and a stand of warm-season grasses provides better wildlife cover and food value than crownvetch. Also, these grasses are native and highly aesthetic. The Department can only benefit if it is able maintain roadway functionality while improving aesthetics and biodiversity along the state's highways.

An issue that will have to be addressed in seed mix evaluations is groundcover. Crownvetch is very effective at covering the soil surface, and less effective at holding soil together. The warm-season grasses are very effective at holding the soil together, and less effective at completely covering the soil at their preferred planting density. Once warm-season grasses are fully established, they will provide the soil cover year round with their persistent residue. However, during the first few seasons after seeding, additional cover will need to be provided by some other component of the mix. A short-lived, low growing species would be ideal. We will be investigating several approaches, such as weeping lovegrass; short-lived legumes; perennial cool-season grasses such as the fescues, which would establish, then fade on some sites; and perhaps even reduced seeding rates of crownvetch. Crownvetch will peacefully co-exist with several of the warm-season grasses. If it is necessary to treat broadleaf weeds in a crownvetch/warm-season grass seeding, the crownvetch could be sacrificed - by the time weeds could become problematic, the grasses would be well established and the crownvetch would not be needed any more.

Stay tuned. We will be searching for sites to conduct these seed mix evaluations. If you are aware of good sites in your district, either due to revitalization, construction, or reconstruction, please let us know.

Peripheral Mower

John Darden of Peripheral Mower, Inc., demonstrated two mowers, a 48-inch unit mounted on a zero-turn radius landscape mower, and a 60-inch three-point hitch unit on a 25 hp tractor. The peripheral mower features a gang of blades on a horizontally-oriented shaft (like a flail mower) that reduces the mowers ability to throw struck objects, due both to the small radius from axle to cutting surface-and therefore reduced blade speed, as well as the ability of the individual blades to slip on the axle when they strike an object providing sufficient resistance. Another proposed benefit of this design is reduced power requirements. The energy savings is partly due to not needing power to generate the 'suction' effect utilized by rotary mowers. The mower was demonstrated at a fairly low (2 inches), as well as a high (4 to 5 inches) cut. The unit was certainly capable of producing an acceptable quality of cut for utility areas at either setting, but did fail to cleanly cut switchgrass clumps (about 42 inches tall, 8 inches across at base) at the higher setting. The side of the clump away from the approaching mower was pushed down before it could be cut cleanly. Smaller grasses such as previously unmowed tall fescue or fine fescues were cut cleanly, however.

Dry Herbicide Injector Demonstration

Ed Bell of Mid-Atlantic Vegetation Management, Inc., graciously provided the services of his Operations Manager, Jim Weikel, and their spray truck equipped with the FlowServe dry injection unit. Their unit was factory-configured to be added to a Mid-Tech controller (configuration for a Raven system is another option). This unit allows for the in-line injection of dry herbicides. The current capacity of the unit allows for application of up to 1.33 lbs of dry herbicide/ac when a swath width of 20 ft is utilized. The manufacturer is in the development stages of increasing the unit's capacity so that diuron could be used at current application rates. Two similar units have been used in the southeast U.S. for Oust applications, and Mid-Atlantic has used their unit extensively for applications of Velpar DF at 21 oz/acre, and Escort applications up to 0.5 oz/acre. Jim demonstrated the calibration of the injector unit, which follows the same procedure as liquid injector calibration, except of course that you measure your pump output with a portable digital scale, rather than with a graduated cylinder.

Increasing the unit's capacity to handle diuron herbicides at current use rates (up to 8 lbs/acre) will provide the first all-injection scenario that does not require any pre-handling (i.e. slurry preparation) of herbicides, liquid or dry.

Brown Brush Monitor Demonstration

This demonstration was made possible through the generosity and efforts of Dow AgroSciences, Arborchem, and Asplundh.

The Brown Brush Monitor is a recent development in the industry's efforts to combine mowing and herbicide application into a single pass operation. The Brush Monitor combines the technology of Brown's tractor-mounted, three-point-hitch brush-mower line with an application system that applies an herbicide solution onto the just-cut stumps. This approach differs from the Lucas-64 and the Burch Wet Blade. The Lucas-64 sprayed herbicide solution under the mower deck and it was deposited on all surfaces under the deck, including the vegetation. The Burch Wet Blade system relies on the aerodynamic qualities of its blades to keep herbicide solution on the lower surface of the blade, which is deposited on the surface of the cut stem as the blade passes through it.

The Brush Monitor relies on two chambers - the cutting and discharge chamber, and the herbicide application chamber. This system keeps the herbicide application equipment separate from the flying debris in the cutting chamber. The application chamber features nozzles directed at the cut stems, as well as scrapers and brushes to further expose and treat cambium tissue on the remaining stumps.

The Brush Monitor can handle brush up to three inches in diameter. Herbicides solution is supplied to the mower at a fixed flow rate, so application rate is dependent upon ground speed. Where brush density is low, ground speed will be faster, and application rate will be lower. Conversely, where brush density is high, ground speed will be reduced, and application rate will be higher.

The site where the unit was demonstrated was marginal in terms of brush size. The Tartarian honeysuckle and staghorn sumac were within the effective size range, but some of the ailanthus was at the large end of the spectrum. To be in the suitable size range, the tractor must be able to readily push over the brush to be mowed. This mower does not have the cutting capacity of the Brown Brush Cutter, which allows the operator to hydraulically lift a corner of the mower deck to expose the blade and back into larger stems. The Brush Monitor could serve a role in reclaiming a moderately overgrown corridor, in conjunction with a chainsaw crew to get the stems that were too large. This could serve as a precursor to implementing a wide-area mowing program to prevent brush reinfestation of mowable terrain. Data reported from Georgia utility trials indicated 80 percent reduction of resprouting compared to mowing alone, and a 25 percent reduction in cost compared to mowing followed by a separate herbicide application.

Hydro-Ax Brush Mower Demonstration

We are very thankful to Dave Fetzer, of Lyons Equipment for committing the considerable effort and expense to demonstrate two substantial pieces of brush clearing equipment - the Hydro-Ax and the Gyro-Trac.

The Hydro-Ax model demonstrated was an articulated loader-type tractor with 150 hp. The hydraulically-driven flail-type cutting head was 8 ft in diameter, and was equipped with hardened blades capable of knocking down (with some effort) trees up to 12 inches in diameter. This unit made light work of the ailanthus on site, handled even large boxelder quite well, and negotiated the slope readily in the recommended up and down (in reverse) direction. The flail head mounts to the loader arms, and can be lifted to cut large branches off of trees before they are mowed. The unit falls within the 8.5 ft width limit, so no 'wide load' provisions are necessary for its transport. One point of consideration for Districts is that this unit could be purchased to serve several stockyard or maintenance functions in addition to brush clearance, since several implements are available, and the tractor already has the auxiliary hydraulic capacity to run them.

The Hydro-Ax would be well-suited for reclaiming severely overgrown corridors, once again in conjunction with a chainsaw crew to handle very large stems. Driving away from the road while cutting is recommended, as the unit does throw a considerable amount of debris, particularly when the cutting head is lifted to de-branch trees prior to cutting them down, or when the cutting teeth strike the soil.

Gyro-Trac Demonstration

The Gyro-Trac is a tracked vehicle equipped with a hydraulically-driven flail-type head. The power unit and cutting capacity of the Gyro-Trac was very similar to the Hydro-Ax. Primary differences are in the vehicle configuration. The Hydro-Ax featured rubber tires and considerable ground clearance, while the Gyro-Trac is a tracked vehicle with less ground clearance, but a lower center-of-gravity. This unit had no difficulty negotiating the slope at the demonstration site. The Gyro-Trac exerts less than 3 psi on the soil surface, and is capable of working in soft, wet soils. The Gyro-Trac is 8.5 ft wide, and therefore does not require wide load provisions.

The Gyro-Trac is a high capacity unit that would be well suited for corridor reclamation, much like the Hydro-Ax, and would provide the flexibility to work in wetter areas without the rutting that could occur with rubber-tired vehicles.

Brown Tree Cutter Demonstration

We would like to thank Gary Menocher of Penn Line Services for transporting and demonstrating their unit, and Mike Maurer for his assistance with choosing the appropriate mower and making the initial contact to Penn Line Services.

The Brown Tree Cutter differs from the Brush Monitor in that it can handle much larger brush, and does not apply pesticide while cutting.

The Brown Tree Cutter is a three-point hitch mounted, PTO driven mower that comes in five models. The unit demonstrated is one of two that feature hydraulically-actuated rear decks that allow the operator to back into standing trees to cut them down, or to close the deck to maximize the chipping action and limit discharge. Depending on the model, the Tree Cutter can handle 6 to 8 inch stems.

The highest capacity Tree Cutter has a 72 inch deck, a 625 lb flywheel, and requires a 90 hp tractor. On the demonstration site, ailanthus up to 4-5 inches could be knocked over by the tractor and cut and mulched with the mower deck closed. Larger stems were backed into to be cut, then driven over. Penn Line commonly equips tractors with a brush rake that mounts like a front end loader. This allows the larger brush to be pushed away if desired, and also makes it easier for the tractor to push over smaller stems.

The Tree Cutter has been used extensively in Districts 3 and 12 for corridor reclamation, in both median and shoulder situations. The hydraulically-actuated rear deck covers significantly reduce the chance of flying woody debris compared to the open-backed units previously discussed.

Asplundh Right-of-Way Trimmer

Asplundh went to considerable effort and expense to bring this unit to the meeting. We are indebted to Tom Mayer, and the crew that travels with the unit for their considerable effort, both quantitative and qualitative.

The Asplundh Right-of-Way Trimmer (ROW Trimmer) was observed by some of the Roadside Specialists at a demonstration in Juniata County in 1996, when it was handled by a company out of Florida, and known as the 'Eliminator'.

The ROW Trimmer features an articulated two-section boom equipped with seven, overlapping, 30-inch circular blades. Four blades are mounted on the lower boom section, three on the upper. Fully extended, the ROW Trimmer can provide 30 feet of vertical clearance. The boom can be oriented anywhere between vertical and horizontal, and can very effectively clear roadside banks. The blades will cleanly cut limbs from one to eight inches in diameter.

This unit is appropriate for large volume clearance. It is commonly employed with a follow-up trimming crew to remove stubs, and a ground crew with a chipper and a skidsteer with a brush claw to provide complete corridor clearance. Such a unit could be employed in mileage-type work where most of the overhanging volume can be removed mechanically, with the trimming crew doing clean-up cutting.

This machine requires wide load hauling, and has a dedicated crew that travels with it.