pennsylvania
DEPARTMENT OF TRANSPORTATION

Roadside Vegetation Management Research – 2026 Report

ANNUAL REPORT

June 30, 2026

By Jeffrey C. Jodon Jr., Connor Hoffman, and Jon M. Johnson

THE PENNSYLVANIA STATE UNIVERSITY

PennState

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

Purchase Order No: 4300710617
Purchase Order Description:
Master Agreement # 4400023298

Technical Report Documentation Page

1. Report No. PA-2026-021-PSU RVM 4300710617	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Roadside Vegetation Management Research – 2026 Report		**5. Report Date** June 30, 2026 **6. Performing Organization Code**
7. Author(s) Jeffrey C. Jodon Jr. Connor Hoffman, and Jon M. Johnson.		**8. Performing Organization Report No.**
9. Performing Organization Name and Address The Pennsylvania State University College of Agricultural Sciences University Park, PA 16802		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** Purchase Order No: 430071067
12. Sponsoring Agency Name and Address The Pennsylvania Department of Transportation Bureau of Planning and Research Commonwealth Keystone Building 400 North Street, 6th Floor Harrisburg, PA 17120-0064		**13. Type of Report and Period Covered** Annual Report: July 1, 2025 – June 30, 2026 **14. Sponsoring Agency Code**
15. Supplementary Notes Project Management – Luke Crawford – Bureau of Operations, Office of Roadside Development		
16. Abstract This report details a cooperative research project performed for the Pennsylvania Department of Transportation's Bureau of Operations by Penn State. The report includes the following: Evaluation of Foliar Applications to Eastern Red Cedar (*Juniperus virginiana*) – Third Year, Evaluation of Eastern Red Cedar (*Juniperus virginiana*) Foliar Applications – Second Year, Evaluation of the Herbicide Detail for Control of Eastern Red Cedar (*Juniperus virginiana*) Using Foliar Applications – Second Year, Efficacy of Foliar Applications of Herbicides or Herbicide Mixes to Eastern Red Cedar (*Juniperus virginiana*) – First Year, Efficacy of Experimental Formulations of Aminocyclopyrachlor Applied as Basal Bark Application on Black Birch – First Year, Evaluation of Herbicide Mixes for the Control of Phragmites (*Phragmites australis*), Evaluation of Plant Growth Regulators and Herbicide Mixes to Manage Turfgrass Near Cable Guiderails, Demonstration of Three Bareground Programs with Alternative Site of Action – Year Three, Efficacy of Frequency in Bareground Applications, Compatibility of Grass and Broadleaf Weed Herbicides Used in Bareground Mixes, Evaluation of Alternative Bareground Mixes and Control on Kochia (*Kochia scoparia*) Along Guiderails.		
17. Key Words Roadside vegetation management, eastern red cedar, Detail, basal bark, black birch, phragmites, plant growth regulator, site of action, Frequency, bareground herbicide mixes, kochia		**18. Distribution Statement** No restrictions. This document is available from the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	**20. Security Classif. (of this page)**	**21. No. of Pages**	**22. Price**
Unclassified	Unclassified	94	

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

ACKNOWLEDGMENTS

This research was funded by the Pennsylvania Department of Transportation, Bureau of Operations, and conducted by the Department of Plant Science, of the College of Agricultural Sciences at Penn State. Personnel contributing to the production of this report include Jeffrey C. Jodon Jr, research support associate, Connor Hoffman, research support associate, and Jon M. Johnson, Director of Pesticide Education at Penn State.

The authors would like to begin by thanking the PennDOT District Roadside Specialists who have been instrumental in locating the field sites needed for this research. Specific mention is needed for Mike Heitzenrater, District 2-0 Roadside Specialist, and Jamie Chestney, District 9-0 Roadside Specialist, as well as the Centre, Juniata and Blair County maintenance personnel who coordinate and work around our many ongoing projects within Centre, Juniata, and Blair, counties. Our sincere appreciation also goes to Luke Crawford, Chief Roadside/Environmental Programs Section and Ray Boronyak, Roadside Manager for their continued support of this research project.

We are grateful for the assistance of the representatives of the various manufacturers providing products for the vegetation management industry, who have lent their time, expertise, and material support on many occasions. The following manufacturers assisted this research project during the 2025 season: BASF Corp., Corteva Agrisciences, Envu, and NuFarm.

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

TABLE OF CONTENTS

INTRODUCTION

In October 1985, personnel at Penn State began a cooperative research project with the Pennsylvania Department of Transportation (PennDOT) to investigate several aspects of roadside vegetation management. An annual report has been submitted each year that describes the research activities and presents the data. The previous reports are listed below:

Report # PA86-018 + 85-08 - Roadside Vegetation Management Research Report

Report # PA87-021 + 85-08 - Roadside Vegetation Management Research Report - Second Year Report

Report # PA89-005 + 85-08 - Roadside Vegetation Management Research Report - Third Year Report

Report # PA90-4620 + 85-08 - Roadside Vegetation Management Research Report - Fourth Year Report

Report # PA91-4620 + 85-08 - Roadside Vegetation Management Research Report - Fifth Year Report

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Report # PA-2012-007-PSU RVM Roadside Vegetation Management Research
– 2012 Report

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

Report # PA-2014-009-PSU RVM Roadside Vegetation Management Research
– 2014 Report

Report # PA-2015-010-PSU RVM Roadside Vegetation Management Research
– 2015 Report

Report # PA-2016-011-PSU RVM Roadside Vegetation Management Research
– 2016 Report

Report # PA-2017-012-PSU RVM Roadside Vegetation Management Research
– 2017 Report

Report # PA-2018-013-PSU RVM Roadside Vegetation Management Research
– 2018 Report

Report # PA-2019-014-PSU RVM Roadside Vegetation Management Research
– 2019 Report

Report # PA-2020-015-PSU RVM Roadside Vegetation Management Research
– 2020 Report

Report # PA-2021-016-PSU RVM Roadside Vegetation Management Research
– 2021 Report

Report # PA-2022-017-PSU RVM Roadside Vegetation Management Research
– 2022 Report

Report # PA-2023-018-PSU RVM Roadside Vegetation Management Research – 2023 Report

Report # PA-2024-019-PSU RVM Roadside Vegetation Management Research – 2024 Report

Report # PA-2025-020-PSU RVM Roadside Vegetation Management Research – 2025 Report

These reports are available by request from the authors and are available online in portable document format (PDF) at https://plantscience.psu.edu/research/projects/vegetation-management/annual-reports.

Use of Statistics in This Report

Many of the individual reports in this document make use of statistical analysis, particularly techniques involved in the analysis of variance. The use of these techniques allows for the establishment of criteria for significance. Numbers are said to be significantly different when the differences between them are most likely due to the different treatments, rather than chance. We have relied almost exclusively on the commonly used probability level of 0.05. When a treatment effect is significant at the 0.05 level, this indicates that there is only a five percent chance that the differences are due to chance alone. Once this level of certainty is reached with the analysis of variance, Tukey's HSD separation test is employed to separate the treatments into groups that are significantly different from each other. In many of our results tables, there is/are a letter or series of letters following each number and a notation which states, 'within each column, numbers followed by the same letter are not significantly different at the 0.05 level'. In addition, absence of letters within a column or the notation 'n.s.' indicates that the numbers in that column are not significantly different from each other at the 0.05 level.

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

Product Information Referenced in This Report

The following details additional information for products referred to in this report. DF = dry flowable, DG = dispersible granules, L = Liquid, EC = emulsifiable concentrate, ME = microencapsulated, MC = microemulsion concentrate, RTU = ready to use, S = solution, SC = suspension concentrate, SG = soluble granule, SL = soluble liquid, WDG=water-dispersible granules, WE= water emulsion, XP= Extruded Paste.

Trade Name	Active Ingredients	Formulation	Manufacturer
ACP120OD-V	experimental	experimental	Envu Environmental Science
ACP120OD-M	experimental	experimental	Envu Environmental Science
Altify IVM	carfentrazone-ethyl	1.9 EC	FMC Corporation
Arsenal Powerline	imazapyr	2 S	BASF Corp.
Detail	saflufenacil	2.85 SC	BASF Corp.
Dicamba 4	dicamba	4 S	
Echelon 4SC	sulfentratzone + prodiamine	4 SC	FMC Corporation
Escort XP	metsulfuron methyl	60 DF	Envu Environmental Science
Esplanade 200 SC	indaziflam	1.67 SC	Envu Environmental Science
Esplanade Sure	indaziflam + rimsulfuron	24.3 + 16.7 WDG	Bayer Environmental Science
Freelexx	2,4-D choline	3.8 S	Corteva Agriscience
Frequency	topramezone	2.8	BASF corp.
Fusilade II	fluazifop-P-butyl	2 EC	Syngenta
Game Up	trinexapac-ethyl	2.5 MC	Loveland Products
Garlon 4	triclopyr ester	4 EC	Corteva Agriscience
Hyvar XL	bromacil	2 SL	Bayer Environmental Science
Method 240SL	aminocyclopyrachlor	2 SL	Envu Environmental Science
Oust Extra	sulfometuron + metsulfuron	56.25 + 15 WDG	Envu Environmental Science
Pendulum Aquacap	pendimethalin	3.8 ME	BASF Corp.
Piper EZ	flumioxazin + pyroxasulfone	33.5+42.5 WDG	Valent USA LLC
Plateau	imazapic	2 S	BASF Corp.
Plainview SC	indaziflam + aminocyclopyrachlor + imazapyr	0.18 + 0.5 + 1.51 SC	Envu Environmental Science
Polaris	imazapyr	2 S	NuFarm Inc.
Portfolio IVM	sulfentrazone	4 SC	Envu Environmental Science
Prodiamine 65 WDG	prodiamine	65 WDG	Alligare LLC
Promenade WDG	flumioxazin	51 WDG	Alligare LLC
RoundUp Custom ATU	glyphosate	4 S	Bayer CropScience
RoundUp Pro Concentrate	glyphosate	3.7 S	Bayer CropScience
Segment II	sethoxydim	1.5 EC	BASF
TerraVue	aminopyralid+florpyrauxifen-benzyl	71 + 6 WDG	Corteva Agriscience
Vastlan	triclopyr choline	4 S	Corteva Agriscience
Vanquish	dicamba	4 S	NuFarm Inc.

EVALUATION OF FOLIAR APPLICATIONS TO EASTERN RED CEDAR
(Juniperus virginiana) 3rd Year

Herbicide trade and common names: Escort XP (*metsulfuron-methyl*), Freelexx (*2, 4-D choline*), *glyphosate 4 lbs. ae/gal,* Method 240SL (*aminocyclopyrachlor*), TerraVue (*aminopyralid + florpyrauxifen-benzyl*), Vanquish *(dicamba),* Vastlan (*triclopyr choline*)

Plant common and scientific name: eastern red cedar (*Juniperus virginiana*)

ABSTRACT

Eastern red cedar has become a problematic native species along Pennsylvania's roadsides. The tree often develops in guiderail sites where common bareground herbicide mixes are applied. The purpose of this experiment was to evaluate foliar applications to the entire canopy of eastern red cedar to determine injury and control based on percent living leaf canopy (LLC). The experiment evaluated eight herbicide treatments: Escort XP at 1, 2, and 3 oz/ac; TerraVue at 2.75 oz/ac + Escort XP at 1 oz/ac; Freelexx at 96 oz/ac + Method 240SL at 16 oz/ac + Escort XP at 1 oz/ac; Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac; Vanquish at 32 oz/ac; glyphosate (4 lb. ae/gal) at 118 oz/ac; and an untreated check. Methylated seed oil at 1% v/v was added to all herbicide mixes. Applications were made at a carrier volume of 35 gallons per acre on May 31, 2023. By July 27, 2023, 57 DAT, no treatment resulted in 100 percent injury. Percent injury of the Escort XP only treatments resulted in less injury (36-42%) than the other herbicide treatments (50-72%). Percent living leaf canopy evaluated on October 26, 2023, 148 DAT, resulted in reduced living leaf canopy for all but one herbicide treatment compared to the untreated check. Only one treatment resulted in similar living leaf canopy to the untreated check, that is Vanquish at 32 oz/ac (73.5%).

One year after application, all herbicide treatments were similar, ranging from 31.25 to 55.5 percent LLC, and significantly reduced living leaf canopy compared to the untreated check (97.1 percent LLC), except Vanquish at 32 oz/ac (79.6 percent LLC) and this trend continued into the next year. By two years after treatment, no treatment resulted in 0 percent living leaf canopy of eastern red cedar. The treatment with the lowest percent living leaf canopy at 42.5 was Escort XP at 2 oz/ac. Glyphosate (4lbs. ae/gal) at 118 oz/ac resulted in 53 percent living leaf canopy. The remaining herbicide treatments were statistically similar to the untreated check as well as statistically similar to Escort XP at 2 oz/ac and glyphosate (4lbs.ae/gal) at 118 oz/ac, except, Vanquish at 32 oz/ac (87.4 percent LLC). It appears that these herbicide treatments applied to eastern red cedar using late spring applications were ineffective.

INTRODUCTION

Eastern red cedar, *Juniperus virginiana,* is native to Pennsylvania, and grows in a wide range of sites and soils in the eastern half of the United States[1]. The plant can grow in soil conditions that range from deep well drained soils associated with agricultural production areas to shallow, rocky outcrops common along roadsides with soils varying in pH from 4.7-7.8[1]. Eastern red cedar can reach a height of 40-50 feet and can sometimes grow as a short shrub. The

[1] https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_1/juniperus/virginiana.htm. Viewed Jan.23, 2024.

bark is gray to reddish brown with peeling strips. Older leaves are opposite, scale-like, in ranks of four[2] with shiny, smooth, dark green foliage[3]. Young needles are linear, pointed, and prickly[3]. Eastern red cedar is a dioecious species reaching sexual maturity at about 10 years[1]. Male trees have yellow-brown cones near the tips, releasing yellow pollen[2] causing the tree to appear yellow brown during pollen release. Female trees produce fleshy bluish green to frosted blue cones ¼ inch in size[2] that are quite attractive producing 1-2 seeds per cone. Eastern red cedar produces some seed every year, however every 2-3 years seed production is quite heavy[1]. The cones do not open and stay on the tree through winter although many are eaten and dispersed by animals, specifically birds. Cones that remain on the tree are dispersed in February or March. Natural germination of the seed typically occurs in the spring of the second year after dispersal due to seed dormancy requirements[4].

Recent observations have demonstrated that eastern red cedar is a growing concern in guiderail sites throughout central and eastern Pennsylvania. In addition, it seems that west of and including the Allegheny Plateau, eastern red cedar is not problematic in guiderails, aligning with its native range. It appears that current herbicides and rates commonly used in bareground mixes are ineffective at controlling established eastern red cedar. The purpose of this experiment was to evaluate foliar applications to the entire canopy of eastern red cedar to determine injury and control based on percent living leaf canopy ratings. Our primary focus was to determine if an herbicide or herbicide mix can effectively control eastern red cedar using spring applied, foliar applications. In the future, an evaluation of current bareground mixes should be made to determine if they are allowing eastern red cedar to germinate from seed, and if so, can we alter those bareground mixes to prevent eastern red cedar seedlings from germinating.

MATERIALS AND METHODS

The experiment was established along SR 22 approximately 2 miles west of the Thompsontown, Pennsylvania exit. With ten trees per replication, each tree was measured to determine the canopy area. The formula used to calculate canopy areas was the surface area of a cylinder ((2 x π x radius x height) + (2 x π x radius^2)) (Appendix Table 1). The herbicide treatment volume was based on the calculated canopy area. The experiment evaluated eight herbicide treatments: Escort XP at 1, 2, and 3 oz/ac; TerraVue at 2.75 oz/ac + Escort XP at 1oz/ac; Freelexx at 96 oz/ac + Method 240SL at 16 oz/ac + Escort XP at 1 oz/ac; Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac; Vanquish at 32 oz/ac; glyphosate (4 lb. ae/gal) at 118 oz/ac; and an untreated check. Methylated seed oil at 1% v/v was added to all herbicide mixes. The application was made at a carrier volume of 35 gallons per acre. All treatments were applied using a CO_2-powered backpack sprayer equipped with a GunJet 30 spray gun and one XP 6 adjustable conejet nozzle operating at 32 PSI (pounds per square inch). The weather at the time of application was sunny and clear skies with wind speeds of 5-10 mph, 40% relative humidity, and air temperatures of 85° F. The treatments were applied on May 31, 2023. An error occurred during the Escort XP at 2 oz/ac application, resulting in 8 replications for this treatment. Plant 76 and 86 were removed from evaluation due to this error.

[2] Manual of Woody Landscape Plants. Michael A Dirr, 1990. Stipes Publishing Company Champaign, Illinois
[3] Important Trees of Eastern Forests. USDA Forest Service, R. W. Neelands 1974. Page28
[4] USDA Agr. Handbook # 271. Eastern red cedar *(Juniperus virginiana)* pp 212-216.

Treatments were visually rated for percent injury where 0 = no injury to 100 = complete injury on June 30, 2023, 30 days after treatment (DAT) and July 27, 2023, 57 DAT. Percent living leaf canopy where 0 = 0 percent living leaf canopy to 100 = 100 percent living leaf canopy were evaluated on October 26, 2023, 148 DAT; June 3, 2024, 1 year after treatment (YAT); and June 2, 2025 (2 YAT). All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Injury to eastern red cedar from the herbicide treatments ranged from 6.4 to 70.5% while the untreated check showed 1.3% natural leaf damage at 30 DAT (Table 1). By 57 DAT, injury increased ranging from 36 to 72 percent, while the untreated check was 1.5%. Conversely, Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac showed a reduction in injury (59.5%) compared to the 30 DAT mark. Herbicide treatments with 50 percent or less injury at 57 DAT included: Vanquish at 32 oz/ac (50%), Escort XP at 1 oz/ac (42%) Escort XP at 2 oz/ac (37.5%), and Escort XP at 3 oz/ac (36%). Herbicide treatments with greater than 50 percent injury included: Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac (59.5%), Freelexx at 96 oz/ac + Method 240SL at 16 oz/ac + Escort XP at 1 oz/ac (60.5%), glyphosate (4 lb. ae/gal) at 118 oz/ac (71%) and TerraVue at 2.75 oz/ac + Escort XP at 1 oz/ac (72%).

On October 26, 2023, 148 DAT, percent living leaf canopy ranged from 95.5 for the untreated check to 31.5 for TerraVue at 2.75 oz/ac + Escort XP at 1 oz/ac. Glyphosate (4 lb. ae/gal) at118 oz/ac resulted in 32.5 percent living leaf canopy while Escort XP at 2 oz/ac resulted in 38.8 percent living leaf canopy. Escort XP at 3 oz/ac resulted in 41 percent living leaf canopy while Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac resulted in 43.5 percent living leaf canopy. Escort XP at 1 oz/ac resulted in 46.7 percent living leaf canopy while Freelexx at 96 oz/ac + Method 240SL at 16 oz/ac + Escort XP at 1 oz/ac resulted in 50.5 percent living leaf canopy and Vanquish at 32 oz/ac resulted in 73.5 percent living leaf canopy. All the herbicide treatments were statistically similar except Vanquish which was the only herbicide treatment statistically similar to the untreated check. Looking closer at Escort XP, it appears that increasing the rate from 1 oz/ac to 2 oz/ac decreased percent living leaf canopy. However, increasing the rate from 2 oz/ac to 3 oz/ac did not reduce percent living leaf canopy. Evaluating mixes that included Escort XP at 1 oz/ac to Escort XP at 1 oz/ac alone, it appears that TerraVue at 2.75 oz/ac + Escort XP at 1 oz/ac and Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac trended toward lower percent living leaf canopy compared to Escort XP at 1 oz/ac alone, though not statistically different.

By June 3, 2024, 1 year after treatment (YAT), percent living leaf canopy ranged from 97.1 for the untreated check to 31.25 for Escort XP at 2 oz/ac. Glyphosate (4lbs. ae/gal) at 118 oz/ac resulted in 40.5 percent living leaf canopy. Both TerraVue at 2.75 oz/ac + Escort XP at 1 oz/ac and Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac resulted in 50 percent living leaf canopy. Escort XP at 3 oz/ac resulted in 53.8 percent living leaf canopy, Escort XP at 1 oz/ac resulted in 54 percent living leaf canopy and Freelexx at 96 oz/ac + Method 240SL at 16 oz/ac + Escort XP at 1 oz/ac resulted in 55.5 percent living leaf canopy. Vanquish resulted in 79.6 percent living leaf canopy and was statistically similar to the untreated check. A similar

trend continued from 148 DAT to 1 YAT as results showed increasing Escort XP from 1 to 2 oz/ac reduced percent living leaf canopy; however, increasing Escort XP from 2 to 3 oz/ac increased percent living leaf canopy. In general, better control is observed when increasing herbicide rates, however we did not see it when increasing Escort XP from 2 oz/ac to 3 oz/ac and we are not sure why. In addition, comparing Escort XP at 1 oz/ac to mixes that included Escort XP at 1 oz/ac showed statistically similar results from 50 to 55.5 percent living leaf canopy. During treatment applications we made certain to cover the entire canopy of eastern red cedar including the inner branches. When evaluating, it was clear that regardless of treatment, most of the living leaf canopy occurred in the inner part of eastern red cedar.

On June 2, 2025, 2 YAT, percent living leaf cover ranged from 96.7 for the untreated check to 42.5 for Escort XP at 2 oz/ac. Glyphosate (4lbs. ae/gal) at 118 oz/ac resulted in 53 percent living leaf canopy. Escort XP at 2 oz/ac and glyphosate (4lbs. ae/gal) at 118 oz/ac were significantly different from the untreated check. The following herbicide treatments were statistically similar to the untreated check as well as statistically similar to Escort XP at 2 oz/ac and glyphosate (4lbs.ae/gal) at 118 oz/ac. Escort XP at 3 oz/ac resulted in 64.3 percent living leaf canopy, while Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac resulted in 68 percent living leaf canopy. The following treatments were all over 70 percent living leaf canopy, Escort XP at 1 oz/ac (71.3%) TerraVue at 2.75 oz/ac + Escort XP at 1 oz/ac (73.5%), Freelexx at 96 oz/ac + Method 240SL at 16 oz/ac + Escort XP at 1 oz/ac (76%), while Vanquish at 32 oz/ac resulted in 87.4 percent living leaf canopy and was statistically similar to the untreated check. Trends observed during 1 YAT ratings were similar to those observed 2 YAT. However, as expected the percent living leaf canopy increased for all herbicide treatments due to continued growth of the eastern red cedar branches not initially injured by the herbicide application.

CONCLUSIONS

Two years after treatment, no treatment resulted in 0 percent living leaf canopy of eastern red cedar. The treatment with the lowest percent living leaf canopy at 42.5 was Escort XP at 2 oz/ac. Glyphosate (4lbs. ae/gal) at 118 oz/ac resulted in 53 percent living leaf canopy. It appears that late spring applications to eastern red cedar were ineffective. While the current concern is eastern red cedar control in guiderail sites, future experiments should evaluate multiple foliar applications to eastern red cedar and efficacy of soil applied herbicides with applications during summer when typical brush control treatments are applied. Also, future work should evaluate preemergence herbicides for effectiveness on preventing eastern red cedar emergence from seed.

MANAGEMENT IMPLICATIONS

Eastern red cedar was not completely controlled with the herbicides evaluated in this experiment. Future experiments should evaluate multiple foliar applications to eastern red cedar to determine control. Escort XP at 2 oz/ac or glyphosate (4 lb. ae/gal) at 118 oz /ac may be considered for spot treating eastern red cedar in guiderail sites that are typically treated with a bareground mix. However, neither product provided complete control at the rates tested.

If treating eastern red cedar in roadside areas where grass groundcover is maintained, several common brush mixes might be considered and include Freelexx at 96 oz/ac + Vastlan at 48 oz/ac + Escort XP at 1 oz/ac, TerraVue at 2.75 oz/ac + Escort XP at 1 oz/ac, or Freelexx at 96 oz/ac + Method 240 SL at 16 oz/ac + Escort XP at 1 oz/ac. While these common brush mixes only marginally reduced the living leaf canopy of eastern red cedar they did result in noticeable plant injury. Perhaps repeated treatments over successive years will offer more complete control. Keep in mind that Escort XP at the 1 oz/ac rate may injure desirable turfgrass species.

One issue to consider is the application time. For this experiment the applications were done the end of May after leaf expansion of eastern red cedar. We thought at this time the waxy surfaces may not have fully developed allowing for easier penetration of the herbicide into the plant. Based on the results, the mixes applied at this late spring timing were ineffective so consider applications after the beginning of July. It is possible, summer to late summer applications will allow the herbicide to translocate to the plant's root system, following the movement of sugars , for potentially better results.

Table 1. Percent injury and living leaf canopy of eastern red cedar *(Juniperus virginiana)*. The experiment was visually rated for percent injury where 0 = no injury to 100 = complete injury on June 30, 2023, 30 days after treatment (DAT) and July 27, 2023, 57 DAT. Percent living leaf canopy where 0 = 0% living leaf canopy to 100 = 100% living leaf canopy were evaluated on October 26, 2023, 148 DAT, June 3, 2024, 1 year after treatment (YAT), and June 2, 2025, 2 YAT. Herbicides were applied on May 31, 2023. All treatments included methylated seed oil at 1% v/v. Each value is the mean of ten replications except untreated and Vanquish at 32 oz/ac which had nine and Escort XP at 2 oz/ac which had eight replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	Rate oz/ac	% Injury 6/30/23 30 DAT	% Injury 7/27/23 57 DAT	% Living Leaf Canopy 10/26/23 148 DAT	% Living Leaf Canopy 6/3/24 1 YAT	% Living Leaf Canopy 6/2/25 2 YAT
Untreated	--	1.3 a	1.5 a	95.5 c	97.1 c	96.7 b
Escort XP	1	13.4 a	42 b	46.7 ab	54 ab	71.3 ab
Escort XP	2	10.9 a	37.5 b	38.8 a	31.25 a	42.5 a
Escort XP	3	6.4 a	36 b	41 a	53.8 ab	64.3 ab
TerraVue Escort XP	2.75 1	61 bc	72 d	31.5 a	50 ab	73.5 ab
Freelexx Method 240SL Escort XP	96 16 1	58 bc	60.5 cd	50.5 ab	55.5 ab	76 ab
Freelexx Vastlan Escort XP	96 48 1	65 c	59.5 cd	43.5 a	50 ab	68 ab
Vanquish	32	46 b	50 bc	73.5 bc	79.6 bc	87.4 b
glyphosate 4lbs ae/gal	118	70.5 c	71 d	32.5 a	40.5 a	53 a

EVALUATION OF EASTERN RED CEDAR *(Juniperus virginiana)* FOLIAR APPLICATIONS
2nd Year

Herbicide trade and *common names*: Detail *(saflufenacil)*, Escort XP *(metsulfuron-methyl)*, Method 240 SL *(aminocyclopyrachlor)*, RoundUp ATU *(glyphosate)*, TerraVue *(aminopyralid + florpyrauxifen-benzyl)*, Vastlan *(triclopyr choline)*

Plant common and *scientific name*: eastern red cedar *(Juniperus virginiana)*

ABSTRACT

Eastern red cedar is a native tree species and an increasing problem along Pennsylvania's roads and guiderails. One cause may be a lack of efficacy with current herbicide treatments. The purpose of this experiment was to test various foliar herbicide treatments and evaluate their efficacy based on plant injury and living leaf canopy. The experiment was designed in response to a lack of strong performance among similar treatments on eastern red cedar conducted in 2023. The current experiment tested six herbicide treatments: Detail at 2 oz/ac; Escort XP at 2 oz/ac; Roundup ATU at 128 oz/ac; TerraVue at 5 oz/ac + Vastlan at 48 oz/ac; TerraVue at 5 oz/ac + Escort XP at 2 oz/ac; Method 240SL at 16 oz/ac + Escort XP at 2 oz/ac, and an untreated check. Methylated seed oil was added to all herbicide treatments at 1 percent v/v. By September 16, 2024, 66 DAT none of the treatment resulted in 100 percent injury. Herbicide treatments with TerraVue had the highest percent injury (85-88.2%) while the Detail treatment produced a significantly lower percent injury (7.8%). The remaining three treatments varied from 60.6-77.8 percent injury. Three treatments produced less than 20 percent living leaf canopy by November 11, 2024 (122 DAT). These included TerraVue at 5 oz/acre + Vastlan at 48 oz/ac (11.7%), TerraVue at 5 oz/ac + Escort XP at 2 oz/acre (11.7%), and Escort XP at 2 oz/ac (12.2%). By July 9, 2025 (1 YAT) Detail at 2 oz/ac remained similar to the untreated check, with 97.8 % living leaf canopy. The remaining five treatments were statistically similar; however, three treatments had percent living leaf canopy under 30 percent and included: Escort XP at 2 oz/ac (25%), TerraVue at 5 oz/ac + Vastlan at 48 oz/ac (27.2%), and Roundup ATU at 128 oz/ac (28.3%).

INTRODUCTION

Eastern red cedar, *Juniperus virginiana,* is a common and problematic species on roadsides in Pennsylvania. A native to the state, eastern red cedar's ability to grow on exposed sites in dry, rocky, poor soils has adapted it well to roadside environments. Eastern red cedar is a dioecious, coniferous tree that can reach heights of 33-66 ft, although in poorer soils it can remain a small shrub[1]. The bark is grey to reddish brown with a shredded, fibrous appearance[5]. The mature needles are oppositely arranged, small, scaly, and overlap the needles above them[6]. The needles range in color from bluish green to pure green[1,2]. Juvenile needles are linear, pointed, and prickly[7]. Eastern red cedar matures and is able to reproduce at around ten years[1]. Female trees have blue to blue green cones that are roughly a ¼ inch in size while male trees have yellow-brown cones producing large quantities of pollen[1]. Seeds are produced every year

[5] https://plants.usda.gov/DocumentLibrary/plantguide/pdf/pg_juvi.pdf. Viewed September.24, 2024.
[6] Manual of Woody Landscape Plants. Michael A Dirr, 1990. Stipes Publishing Company Champaign, Illinois
[7] Important Trees of Eastern Forests. USDA Forest Service, R. W. Neelands 1974. Page 24

with notably higher seed production observed every two to three years[1]. The female cones remain throughout winter and do not open. Seeds are eaten and dispersed by animals or fall off the plant around February. Germination of the seed typically happens in the spring after two years in the environment[8].

Current herbicide mixes do not seem to provide the desired control of eastern red cedar therefore necessitating the testing of alternative herbicide mixes for the species. This is the second iteration of an experiment with new herbicide mixes and rates in response to a 2023 experiment where the results were not effective in control of eastern red cedar.

MATERIALS AND METHODS

The experiment was conducted on two sites, the first being along SR 22 approximately two miles west of Thompsontown, PA and the second along I-99 approximately ½ mile north of the SR150 exit. Each treatment consisted of nine replications (trees) that were measured for canopy area. The formula used to determine canopy area was the surface area of a cylinder calculated as (2 x pi x radius x height) + (2 x pi x radius^2) (Appendix Table 1). The calculated canopy area determined the total amount of the herbicide mix used per plant. There were six herbicide treatments in addition to an untreated check including: Detail at 2 oz/ac; Escort XP at 2 oz/ac; TerraVue at 5 oz/ac + Vastlan at 48 oz/ac; TerraVue at 5 oz/ac + Escort XP at 2 oz/ac; Method 240SL at 16 oz/ac + Escort XP at 2 oz/ac; and Roundup ATU at 128 oz/ac. Methylated seed oil at 1 percent v/v was added to each herbicide mix. The carrier volume was 35 gallons per acre. A CO_2-powered backpack sprayer applied treatments using a GunJet 30 spray gun equipped with one PPX 6 adjustable nozzle operating at a pressure of 31 PSI (pounds per square inch). The weather at the time of application for the SR 322 site was sunny and clear with wind speeds of 5-10 mph, 94 percent humidity, and air temperature of 74° F. The weather at the time of application for the I-99 site was sunny and clear with wind speeds of 5-10 mph, 94 percent humidity, and air temperature of 83° F. Both applications were made on July 12, 2024.

Treatments were visually rated for percent injury where 0 = no injury and 100 = complete injury and living leaf canopy where 0 = 0 percent living leaf canopy to 100 = 100 percent living leaf canopy. Ratings for injury were done on August 14, 2024, 33 DAT (days after treatment) and September 16, 2024, 66 DAT. Ratings for living leaf canopy were done November 11, 2024 (122 DAT and July 9, 2025, 1 year after treatment (YAT). All data was subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Injury from the herbicide treatments ranged from 9.4 to 85.6 percent while the untreated check showed 4.9 percent natural injury on August 14, 2024, 33 DAT (Table 1). On September 16, 2024, 66 DAT, treatments varied from 7.8 to 88.2 percent injury with the untreated check at 6.1 percent natural injury. Percent injury increased for all treatments at 66 DAT except for Detail at 2 oz/ac which reduced from 9.4 at 33 DAT to 7.8 percent injury at 66 DAT. The remaining five herbicide treatments showed increased injury levels above 60 percent at 66 DAT including Escort

[8] USDA Agr. Handbook #271. Eastern red cedar (Juniperus virginiana) pp 212-216

XP at 2 oz/ac (60.6%), TerraVue at 5 oz/ac + Vastlan at 48oz/ac (88.2%), TerraVue at 5 oz/ac + Escort XP oz/ac (85.0%), Method 240SL at 16 oz/ac + Escort XP at 2 oz/ac (64.4%), RoundUp ATU at 128 oz/ac (77.8%).

By November 11, 2024, 122 DAT, percent living leaf canopy ranged from 84.9 for the untreated check to 11.7 for both TerraVue at 5 oz/ac + Vastlan at 48 oz/ac and TerraVue at 5 oz/ac + Escort XP at 2 oz/ac. Detail at 2 oz/ac had similar living leaf canopy to the untreated check at 84.8 percent. Herbicide treatments with a living leaf canopy below 25 percent at 122 DAT included Escort XP at 2 oz/ac (12.2%), TerraVue at 5 oz/ac + Vastlan at 48 oz/ac (11.7%), TerraVue at 5 oz/ac + Escort XP at 2 oz/ac (11.7%), Method 240SL at 16 oz/ac + Escort XP at 2 oz/ac (22.4%), and RoundUp ATU at 128 oz/ac (20.3%). The lowest percent living leaf canopy from the 2023 experiment was TerraVue at 2.75 oz/ac and Escort XP at 1 oz/ac (31.5%) at 148 DAT which was the last rating[9]. By the final 2024 rating, 122 DAT, all herbicide mixes had a significantly lower percent living leaf canopy compared to Detail at 2 oz/ac (84.8%) and the untreated check (84.9%) ranging from 11.7 to 22.4%. One factor that may have resulted in the lower percent living leaf canopy during the 2024 experiment is the higher rate of TerraVue and Escort XP compared to the 2023 experiment. Another factor that may have influenced the lower percent living leaf canopy of some treatments is application time. During the 2023 experiment the application was May 30 whereas the 2024 experiment was applied July 12 which is more consistent with typical brush applications. Two treatments, RoundUp ATU at 128 oz/ac and Escort XP at 2 oz/ac, were identical rates for both the 2023 and 2024 experiments but the percent living leaf canopy was lower in 2024. With applications in July, it is more likely that sugars are moving from the leaves to the roots thereby moving the herbicide in the same direction potentially resulting in greater injury.

By July 9, 2025, 1 YAT, percent living leaf canopy ranged from 97.8 to 25 percent. Detail at 2 oz/ac had the highest living leaf canopy at 97.8 percent followed closely by the untreated check at 97.2 percent with both being statistically similar. The remaining treatments were statistically similar to one another, ranging from 25 to 52.8 living leaf canopy. Herbicide treatments below 30 percent living leaf canopy were Escort XP at 2 oz/ac (25%), TerraVue at 5 oz/ac + Vastlan at 48 oz/ac (27.2%), and RoundUp ATU at 128 oz/ac (28.3%). TerraVue at 5 oz/ac + Escort XP at 2 oz/ac and Method 240 SL at 16 oz/ac + Escort XP at 2 oz/ac had a living leaf canopy of 42.8 and 52.8 percent, respectively. All treatments saw an increase in living leaf canopy from the previous rating on November 11, 2024, the prior fall. TerraVue at 5 oz/ac + Escort XP at 2 oz/ac and Method 240 SL at 16 oz/ac + Escort XP at 2 oz/ac had the largest increase in living leaf canopy between the last two ratings with an increase of 31.1 and 30.4 percent, respectively. Interestingly Escort XP by itself at 2 oz/ac had the lowest living leaf canopy while the other two treatments containing Escort XP at 2 oz/ac in the mix had a noticeably higher percent living leaf canopy even though they were still statistically similar. A possible explanation for the increase in living leaf canopy at 1 YAT is that the rating the previous year was taken in November after several hard frosts and that may have been responsible for the foliar damage. Another possible reason could be from new regrowth that occurred. The lowest percent living leaf canopy for the 2023 eastern red cedar experiment at 1 YAT was Escort XP at 2

[9] Jodon et. Al. 2024. Evaluation of Foliar Applications to Eastern Red Cedar – Year One. Roadside Vegetation Management Research-2024 Report. pp. 7.

oz/ac (31.3%)[10]. Escort XP at 2 oz/ac (25%), TerraVue at 5 oz/ac + Vastlan at 48 oz/ac (27.2%), and RoundUp ATU at 128 oz/ac (28.3%) all achieved lower percent living leaf canopies compared to the 2023 eastern red cedar experiment possibly due to the later application timing. Also, it is notable that Escort XP at 2 oz/ac was the most effective treatment at 1 YAT for both the 2023 and 2024 experiments.

CONCLUSION

No treatments resulted in complete loss of living leaf canopy by July 9, 2025, 1 YAT. The treatment with the lowest percent living leaf canopy was Escort XP at 2 oz/ac (25%). Other effective treatments were TerraVue at 5 oz/ac + Vastlan at 48 oz/ac and RoundUp ATU at 128 oz/ac at 27.2 and 28.3, respectively. All three of these herbicide treatments achieved a lower living leaf canopy than the best performing treatment from the 2023 experiment. Future research for eastern red cedar control includes investigating multiple foliar applications per year, sequential applications 2 or 3 years after the initial treatment, and the testing of different herbicide mixes to completely control eastern red cedar in roadside settings. Additionally, evaluating different herbicide mixes in guiderail settings to prevent or control eastern red cedar seedlings is a research need.

MANAGEMENT IMPLICATIONS

With no complete control of eastern red cedar yet observed with any treatment mix, future experiments should be conducted to determine the efficacy of multiple foliar treatments. Furthermore, this experiment found several herbicide treatments that were similarly viable for use when considering percent living leaf canopy reduction: Escort XP at 2 oz/ac (25%), TerraVue at 5 oz/ac + Vastlan at 48 oz/ac (27.2%), and RoundUp ATU at 128 oz/ac (28.3%). These treatment mixes could all be used for spot treating eastern red cedar while maintaining similar efficacy. When treating areas with grass cover TerraVue at 5 oz/ac + Vastlan at 48 oz/ac should be used to avoid unwanted damage to turf. Future data collection will be required to determine long-term living leaf canopy reduction and future recommendations.

[10] Jodon et. Al. 2025. Evaluation of Foliar Applications to Eastern Red Cedar – Second Year. Roadside Vegetation Management Research-2025 Report. pp. 5.

Table 1. Percent injury and living leaf canopy of eastern red cedar *(Juniperus virginiana)*. The experiment was visually rated for percent injury where 0 = no injury to 100 = complete injury on August 14, 2024, 33 DAT (days after treatment) and September 16, 2024, 66 DAT and percent living leaf canopy where 0 = 0% living leaf canopy to 100 = 100% living leaf canopy on November 11, 2024, 122 DAT and July 9, 2025, 1 YAT. All treatments included methylated seed oil at 1 percent v/v. Herbicide treatments were applied July 12, 2024. Each value is the mean of nine replications. Column means followed by the same letters are not significantly different at $p \leq 0.05$.

Treatment	Product	Rate oz/ac	% Injury 8/14/24 33 DAT	% Injury 9/16/24 66 DAT	% Living Leaf Canopy 11/11/24 122 DAT	% Living Leaf Canopy 7/9/25 1 YAT
1	Untreated	--	4.9 a	6.1 a	84.9 b	97.2 b
2	Detail	2	9.4 a	7.8 a	84.8 b	97.8 b
3	Escort XP	2	40.6 b	60.6 b	12.2 a	25 a
4	TerraVue Vastlan	5 48	85.6 d	88 .2 d	11.7 a	27.2 a
5	TerraVue Escort XP	5 2	73.3 d	85 d	11.7 a	42.8 a
6	Method 240SL Escort XP	16 2	53.3 bc	64.4 bc	22.4 a	52.8 a
7	RoundUp ATU	128	70 cd	77.8 cd	20.3 a	28.3 a

EVALUATION OF THE HERBICIDE DETAIL FOR CONTROL OF EASTERN RED CEDAR *(Juniperus virginiana)* USING FOLIAR APPLICATIONS-2nd Year

Herbicide trade and *common names*: Detail *(saflufenacil)*
Plant common and *scientific name*: eastern red cedar *(Juniperus virginiana)*

ABSTRACT

The purpose of the experiment was to determine if Detail herbicide had potential for controlling eastern red cedar with foliar treatments. The experiment evaluated three rates of Detail at 2, 4, and 6 oz/acre. Treatments were applied on October 3, 2024. The effectiveness of each treatment was measured by evaluating percent injury. Evaluations made on November 4, 2024, 32 DAT showed Detail at 2 oz/acre with 2.6, Detail at 4 oz/acre with 4.1, and Detail at 6 oz/acre with 1.4 percent injury. No significant difference in injury was found between treatments compared to the untreated control. Percent living leaf canopy (LLC) was evaluated both on July 10, 2025, 280 days after treatment (DAT) and October 1, 2025, 363 DAT. The results indicated no significant difference in LLC for any treatment compared to the untreated check. At 363 DAT, treatments ranged from 98.9 to 99.7 LLC while the untreated check was 99.7 LLC. The rates of Detail tested in this experiment were ineffective at controlling eastern red cedar using foliar applications.

INTRODUCTION

Eastern red cedar is a problematic species along Pennsylvania roadsides, often found near guiderails, signposts and other areas where total vegetation control is desired. To address difficulties in controlling eastern red cedar, new herbicides are being tested as they are identified to see if they can provide effective control. Detail is an herbicide that was considered for potential use in controlling eastern red cedar.

MATERIALS AND METHODS

The experiment was conducted on a site along I-99 approximately ½ mile north of the SR150 exit, near Bellefonte, PA. Each treatment had seven replications (individual trees) that were measured for canopy area. The formula used to determine canopy area was the surface area of a cylinder (2 x pi x radius x height) + (2 x pi x radius^2) (Appendix Table 1). The calculated canopy area determined the total amount of the herbicide used per replicate (individual tree). The application was made on October 3, 2024. There were three herbicide treatments, Detail at 2, 4, and 6 oz/ac, in addition to an untreated check. Methylated seed oil at 1 percent v/v was added to each herbicide mix. The carrier volume was 35 gallons per acre. Treatments were applied with a CO_2-powered backpack sprayer equipped with a GunJet 30 spray gun and PPX 6 adjustable nozzle operating at 31 PSI (pounds per square inch). The weather at the time of application was overcast with fog, 5-10 mph wind speed, 98 percent relative humidity, and air temperature of 83° F.

Treatments were visually rated for percent injury where 0 = no injury and 100 = complete injury on November 4, 2024, 32 DAT (days after treatment) and percent living leaf canopy (LLC) on July 10, 2025, 280 days after treatment (DAT) and October 1, 2025 (363 DAT). All data was subjected to analysis of variance and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

The percent injury on November 4, 2024, 32 DAT included Detail at 2 oz/acre with 2.6 percent, Detail at 4 oz/acre with 4.1 percent, and Detail at 6 oz/acre with 1.4 percent. (Table 1). Treatments did not differ significantly from the untreated check which had an injury value of 3 percent. The naturally occurring injury on the untreated trees was found to be comparable to the treatment effects. This suggests that little initial injury was observable from the treatments by 32 DAT. By July 10, 2025, 280 DAT, percent living leaf canopy for the herbicide treatments ranged from 97.4 to 99, while the untreated was 98.6 percent. On October 1, 2025**,** 363 DAT, the untreated showed 99.7 percent living leaf canopy while the herbicide treatments showed: Detail at 2 oz/ac 99.3 percent living leaf canopy, Detail at 4 oz/ac 99.7 percent living leaf canopy, and Detail at 6 oz/ac 98.9 percent living leaf canopy with no significant treatment effect for any rate of Detail tested.

CONCLUSION

No herbicide treatment differed significantly from the untreated check in percent injury 32 DAT and percent living leaf canopy at 280 or 363 DAT. It appears that applications of Detail at 2 oz/ac 4 oz/ac or 6 oz/ac had no activity on eastern red cedar one year after treatment. Evaluations will be made in 2026, 2 years after treatment to confirm there is no change in injury to the trees. It is possible that the fall timing of the application could have influenced the results. Future research should evaluate applying treatments of Detail earlier in the growing season. Also, determine if the addition of Detail to herbicide mixes might show increased activity on eastern red cedar.

MANAGEMENT IMPLICATIONS

Detail at 2 oz/ac, 4 oz/ac or 6 oz/ac applied alone is not recommended for control of eastern red cedar. However, testing the addition of Detail to herbicides like RoundUp Pro Concentrate or Escort XP and herbicide mixes like TerraVue + Vastlan should be done to investigate the efficacy on eastern red cedar.

Table 1. Percent injury and living leaf canopy of eastern red cedar *(Juniperus virginiana)*. The experiment was visually rated for percent injury where 0 = no injury to 100 = complete injury on November 4, 2024, 32 DAT (days after treatment) and percent living leaf canopy where 0 = 0% living leaf canopy to 100 = 100% living leaf canopy on July 10, 2025 (280 DAT) and on October 1, 2025 (363 DAT). All treatments included methylated seed oil at 1 percent v/v. Each value is the mean of seven replications. Column means followed by the same letters are not significantly different at $p \leq 0.05$.

Product	Rate oz/ac	% Injury 11/4/24 32 DAT	% Living Leaf Canopy 7/10/25 280 DAT	% Living Leaf Canopy 10/1/25 363 DAT
Untreated	--	3	98.6	99.7
Detail	2	2.6	99	99.3
Detail	4	4.1	98.7	99.7
Detail	6	1.4	97.4	98.9
		n.s.	n.s.	n.s.

EFFICACY OF FOLIAR APPLICATIONS OF HERBICIDES OR HERBICIDE MIXES TO EASTERN RED CEDAR *(Juniperus virginiana)* 1st Year

Herbicide trade and common names: Detail *(saflufenacil)*, Escort XP *(metsulfuron-methyl*), RoundUp Pro Concentrate *(glyphosate),* TerraVue (*aminopyralid + florpyrauxifen-benzyl*), Vastlan (*triclopyr choline*)

Plant common and scientific name: eastern red cedar (*Juniperus virginiana*)

ABSTRACT

Eastern red cedar is a native species that has become a problematic along Pennsylvania's roadsides. The tree often develops in guiderail sites or around signposts where common bareground herbicide mixes are applied. The purpose of this experiment was to evaluate foliar applications to the entire canopy of eastern red cedar to determine injury and control based on percent living leaf canopy. The experiment evaluated ten herbicide treatments: Detail at 2 oz/ac + Round Up Pro Concentrate at 64 oz/ac, Escort XP at 2 oz/ac + Round Up Pro Concentrate at 128 oz/ac, Escort XP at 2 oz/ac, TerraVue at 5 oz/ac + Vastlan at 48 oz/ac, Round Up Pro Concentrate at 128 oz/ac, Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac, Detail at 2 oz/ac + Round Up Pro Concentrate at 128 oz/ac, Detail at 2 oz/ac + Escort XP at 2 oz/ac + Round Up Pro Concentrate at 128 oz/ac, Detail at 2 oz/ac + Escort XP at 2 oz/ac, and an untreated check. Methylated seed oil at 2% v/v was added to all herbicide mixes. Applications were made at a carrier volume of 35 gallons per acre on July 22, 2025. By September 24, 2025, 64 DAT, none of the treatments resulted in 100 percent injury. Two treatments resulted in over 90 percent injury, Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac and TerraVue at 5 oz/ac + Vastlan at 48 oz/ac. Percent living leaf canopy evaluated on October 29, 2025 showed no treatments with complete loss of living leaf canopy. Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac resulted in 1.5 percent living leaf canopy while TerraVue at 5 oz/ac + Vastlan at 48 oz/ac resulted in 3.5 percent living leaf canopy.

INTRODUCTION

Eastern red cedar, *Juniperus virginiana* is native to Pennsylvania and grows in a wide range of sites and soils in the eastern half of the United States[11]. Recent observations have demonstrated that eastern red cedar is a growing concern in guiderail sites throughout central and eastern Pennsylvania. In addition, it seems that west of and including the Allegheny Plateau, eastern red cedar is not problematic in guiderails, aligning with its native range. It appears that current herbicides and rates commonly used in bareground mixes are ineffective at controlling established eastern red cedar. The project has been evaluating herbicides and herbicide mixes to determine efficacy of foliar application to eastern red cedar[12,13]. The purpose of this experiment

[11] https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_1/juniperus/virginiana.htm. Viewed April, 2026.
[12] Jodon et. Al. 2026. Evaluation of Foliar Applications to Eastern Red Cedar 3rd Year. Roadside Vegetation Management Research-2026 Report. pp. 1.
[13] Jodon et. Al. 2026. Evaluation of Eastern Red Cedar (*Juniperus virginiana*) Foliar Applications 2nd Year. Roadside Vegetation Management Research-2026 Report. pp. 1.

was to evaluate foliar applications to the entire canopy of eastern red cedar to assess injury of herbicide treatments and control based on living leaf canopy. Herbicide treatments were selected based on past experiments and recommendations from industry representatives.

MATERIALS AND METHODS

The experiment was established at two sites in Juniata county: along SR 22 approximately 2 miles west of the Thompsontown, Pennsylvania exit and along SR22 approximately ½ mile west of the Port Royal, Pennsylvania exit. With one tree serving as a replicate, each tree was measured to determine the canopy area. The formula used to calculate canopy areas was the surface area of a cylinder ($(2 \times \pi \times \text{radius} \times \text{height}) + (2 \times \pi \times \text{radius}^2)$) (Appendix Table 1). The treatment volume was based on the calculated canopy area. The experiment evaluated ten herbicide treatments: Detail at 2 oz/ac + Round Up Pro Concentrate at 64 oz/ac, Escort XP at 2 oz/ac + Round Up Pro Concentrate at 128 oz/ac, Escort XP at 2 oz/ac, TerraVue at 5 oz/ac + Vastlan at 48 oz/ac, Round Up Pro Concentrate at 128 oz/ac, Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac, Detail at 2 oz/ac + Round Up Pro Concentrate at 128 oz/ac, Detail at 2 oz/ac + Escort XP at 2 oz/ac + Round Up Pro Concentrate at 128 oz/ac, Detail at 2 oz/ac + Escort XP at 2 oz/ac, and an untreated check. Methylated seed oil at 2% v/v was added to all herbicide mixes. The application was made at a carrier volume of 35 gallons per acre. All treatments were applied using a CO_2-powered backpack sprayer equipped with a GunJet 30 spray gun and one XP 6 adjustable conejet nozzle operating at 32 PSI (pounds per square inch). The weather at the time of application was sunny, with wind speeds of 0-5 mph, 56% relative humidity, and air temperature of 78° F. The treatments were applied on July 22, 2025. Unfortunately, several weeks after the applications, the site west of Port Royal was over sprayed by the contractor during normal weed and brush operations, so 6 replications were lost and not included with data collection and analysis. The result was 4 replications per treatment instead of 10.

Treatments were visually rated for percent injury where 0 = no injury to 100 = complete injury on August 26, 2025, 35 days after treatment (DAT) and September 24, 2025, 64 DAT. Percent living leaf canopy where 0 = 0 percent living leaf canopy to 100 = 100 percent living leaf canopy were evaluated on October 29, 2025, 99 DAT. All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Injury to eastern red cedar from the herbicide treatments ranged from 9.5 to 93.75 percent while the untreated check showed 4.75 percent natural leaf damage at 35 DAT (Table 1). By 64 DAT, injury increased for all herbicide treatments ranging from 21.25 to 97.25 percent, while the untreated check was 5.5 percent. Herbicide treatments with less than 50 percent injury at 64 DAT included: Escort XP at 2 oz/ac (21.25%), Detail at 2 oz/ac + Escort XP at 2 oz/ac (43.75%), and Detail at 2 oz/ac + RoundUp Pro Concentrate at 64 oz/ac (48.75%). Herbicide treatments with greater than 50 percent injury included: Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac (68%), Detail at 2 oz/ac + Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac (72.5%), Detail at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac (76.25%), RoundUp

Pro Concentrate at 128 oz/ac (85%), TerraVue at 5 oz/ac + Vastlan at 48 oz/ac (94.75%), and Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac (97.25%).

On October 29, 2025, 99 DAT, percent living leaf canopy ranged from 92.5 for the untreated check to 1.5 for Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac. TerraVue at 5 oz/ac + Vastlan at 48 oz/ac resulted in 3.5 percent living leaf canopy. RoundUp Pro Concentrate at 128 oz/ac resulted in 6.75 percent living leaf canopy while Detail 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac resulted in 12.75 percent living leaf canopy. Detail at 2 oz/ac + RoundUp Pro Concentrate at 64 oz/ac resulted in 45 percent living leaf canopy. Detail at 2 oz/ac + Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac resulted in 20 percent living leaf canopy while Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac resulted in 25 percent living leaf canopy. Detail at 2 oz/ac + Escort XP at 2 oz/ac resulted in 37.5 percent living leaf canopy while Escort XP at 2 oz/ac resulted in 67.5 percent living leaf canopy.

Comparing similar treatments with and without Detail showed mixed results. For example, Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac had statistically similar but slightly less living leaf canopy than TerraVue at 5 oz/ac + Vastlan at 48 oz/ac. Likewise, Detail at 2 oz/ac + Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac had statistically similar but slightly less living leaf canopy than Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac. Interestingly, RoundUp Pro Concentrate at 128 oz/ac had significantly less living leaf canopy than Detail 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac.

The two treatments with the least living leaf canopy, Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac and TerraVue at 5 oz/ac + Vastlan at 48 oz/ac were statistically similar to the following: RoundUp Pro Concentrate at 128 oz/ac, Detail 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac, Detail at 2 oz/ac + Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac, and Escort XP at 2 oz/ac + RoundUp Pro Concentrate at 128 oz/ac.

Methylated seed oil (MSO) was added at 2 percent volume per volume (v/v) to all herbicide treatments. The eastern red cedar experiment initiated in 2024[14] had 1 percent v/v MSO added to all herbicide treatments. Three similar treatments were used to compare whether the higher percent MSO v/v improved efficacy and included: Escort XP at 2oz/ac, RoundUp Pro Concentrate at 128 oz/ac, and TerraVue at 5 oz/ac + Vastlan at 48 oz/ac. Both experiments (2024 vs. 2025) were applied in July. It appears that the MSO at 2 percent v/v used in 2025 showed not only higher injury 2 months after treatment but also less living leaf canopy by the end of the first season, when compared to 2024 treatments with MSO at 1 percent v/v for TerraVue at 5 oz/ac + Vastlan at 48 oz/ac and RoundUp Pro Concentrate at 128 oz/ac, possibly due to a higher amount of methylated seed oil allowing greater penetration of herbicide into the plant. One difference to highlight which may have impacted efficacy of the *glyphosate* treatments is that in 2024 RoundUp Custom ATU was used, which doesn't have the surfactant load included with RoundUp Pro Concentrate. The additional surfactant load in RoundUp Pro Concentrate may have assisted in the increased efficacy noted. Surprisingly, when comparing the Escort XP at 2 oz/ac treatment between 2024 and 2025, Escort XP at 2 oz/ac with 1% v/v MSO (2024) showed higher injury 2 months after treatment and less living leaf canopy by the

[14] Jodon et. Al. 2026. Evaluation of Eastern Red Cedar (*Juniperus virginiana*) Foliar Applications 2nd Year. Roadside Vegetation Management Research-2026 Report. pp. 7.

end of the first season. We cannot determine the cause of this result. Additional ratings will clarify and determine if this continues one year after treatment.

CONCLUSIONS

By September 24, 2025, 64 DAT, none of the treatments resulted in 100 percent injury. Two treatments resulted in over 90 percent injury, Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac and TerraVue at 5 oz/ac + Vastlan at 48 oz/ac. Percent living leaf canopy evaluated on October 29, 2025, showed no treatments with 0 percent living leaf canopy. Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac resulted in 1.5 percent living leaf canopy while TerraVue at 5 oz/ac + Vastlan at 48 oz/ac resulted in 3.5 percent living leaf canopy. Future research will continue to rate the amount of living leaf canopy one and two years after treatment to determine the long term effects of the treatments.

MANAGEMENT IMPLICATIONS

Eastern red cedar was not completely controlled at this point with the herbicides evaluated in this experiment. Future observations and data collection will determine if complete control is achieved one year after treatment. To completely control eastern red cedar, multiple foliar applications may be needed over successive growing seasons. For spot treatments, RoundUp Pro Concentrate at 128 oz/ac or Escort XP at 2 oz/ac are recommended. However, if trends continue to show Escort XP at 2 oz/ac to be less effective than previous experiments, this particular recommendation may be altered. If treating eastern red cedar in roadside areas where grass groundcover is maintained, several mixes might be considered: Detail at 2 oz/ac + TerraVue at 5 oz/ac + Vastlan at 48 oz/ac and TerraVue at 5 oz/ac + Vastlan at 48 oz/ac. The addition of Detail at 2 oz/ac to mixes has shown mixed results so far when comparing similar mixes with or without Detail. The cost of the product may influence decisions on whether or not to add it to an herbicide mix applied to eastern red cedar. Increasing the percent of MSO to 2 percent v/v appears to increase efficacy of treatments. Future observations, along with data collection and analysis conducted one and two years after treatment, will inform subsequent recommendations.

Table 1. Percent injury and living leaf canopy of eastern red cedar *(Juniperus virginiana)*. The experiment was visually rated for percent injury 0 = no injury to 100 = complete injury on August 26, 2025, 35 days after treatment (DAT) and September 24, 2025, 64 DAT. Percent living leaf canopy where 0 = 0 percent living leaf canopy to 100 = 100 percent living leaf canopy were evaluated on October 29, 2025, 99 DAT. Herbicides were applied on July 22, 2025. All treatments included methylated seed oil at 2% v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Product	Rate oz/ac	% Injury 8/26/25 35 DAT	% Injury 9/24/25 64 DAT	% Living Leaf Cover 10/29/25 99 DAT
1	Untreated	--	4.75 a	5.5 a	92.5 e
2	Detail RoundUp Pro Concentrate	2 64	33.75 abc	48.75 bcd	45 cd
3	Escort XP RoundUp Pro Concentrate	2 128	45 c	68 cde	25 abc
4	Escort XP	2	9.5 ab	21.25 ab	67.5 de
5	TerraVue Vastlan	5 48	88.75 d	94.75 e	3.5 a
6	RoundUp Pro Concentrate	128	53.75 c	85 de	6.75 ab
7	Detail TerraVue Vastlan	2 5 48	93.75 d	97.25 e	1.5 a
8	Detail RoundUp Pro Concentrate	2 128	45 c	76.25 cde	12.75 ab
9	Detail Escort XP RoundUp Pro Concentrate	2 2 128	38.75 bc	72.5 cde	20 abc
10	Detail Escort XP	2 2	22.5 abc	43.75 bc	37.5 bcd

EFFICACY OF EXPERIMENTAL FORMULATIONS OF AMINOCYCLOPYRACHLOR APPLIED AS BASAL BARK APPLICATION ON BLACK BIRCH *(Betula lenta)*

Herbicide trade and common names: ACP120OD-V *(experimental formulation)*, ACP120OD-M *(experimental formulation)*, Method 240SL *(aminocyclopyrachlor)*, Garlon 4 *(triclopyr ester)*
Plant common and scientific name: black birch *(Betula lenta)*

ABSTRACT

Basal bark applications are commonly utilized on roadside sites to manage unwanted tree species. An experiment was established to evaluate various basal bark treatments applied to black birch *(Betula lenta)* on November 12, 2024 near Port Matilda, PA. The treatments included ACP 120OD-V 5% v/v + Arborchem TG Oil 95% v/v; ACP 120OD-V 10% v/v + Arborchem TG Oil 90% v/v; ACP 120OD-V 20% v/v + Arborchem TG Oil 80% v/v; ACP 120OD-M 5% v/v + Arborchem TG Oil 95% v/v; ACP 120OD-M 10% v/v + Arborchem TG Oil 90% v/v; ACP 120OD-M 20% v/v + Arborchem TG Oil 80% v/v; Method 240SL 2.5% v/v + Arborchem TG Oil 97.5% v/v; Method 240SL 5% v/v + Arborchem TG Oil 95% v/v; Method 240SL 10% v/v + Arborchem TG Oil 90% v/v; and Garlon 4 25% v/v + Arborchem TG Oil 75% v/v. About one year after treatment, Garlon 4 25%v/v + Arborchem TG Oil 75%v/v showed the lowest percent leaf canopy on black birch while the other herbicide treatments were statistically similar to the untreated.

INTRODUCTION

Basal bark applications target individual stems with treatments applied around the entire stem from ground level up 12-18 inches. This treatment method is used to treat stems with a diameter of 6 inches or less. Herbicides are combined with basal oil to penetrate the bark then enter the vascular system. Application rates for the herbicide and the carrier oil are described as volume to volume. The standard mix for basal bark treatments has been Garlon 4 at 25% v/v and basal oil at 75% v/v. Applications are done with backpacks and an ultra-low volume wand to minimize drip. Basal bark applications focus on roadside sites with a low density of targeted trees.

MATERIALS AND METHODS

An experiment was established November 12, 2024 near Port Matilda, PA to evaluate the efficacy of two experimental formulations of aminocyclopyrachlor (ACP 120OD-V AND ACP120-OD-M) plus oil at various percent volume per volume rates, Method 240SL plus oil at various percent volume per volume rates, and Garlon 4 plus oil as basal bark applications to black birch *(Betula lenta)*. Individual tree diameter was measured six inches above the soil line prior to the applications. This information can be found in the appendix of this report. The experiment was arranged as a completely randomized design with nine replications per treatment. An individual tree represents one replication. The treatments included ACP 120OD-V 5% v/v + Arborchem TG Oil 95% v/v; ACP 120OD-V 10% v/v + Arborchem TG Oil 90% v/v; ACP 120OD-V 20% v/v + Arborchem TG Oil 80% v/v; ACP 120OD-M 5% v/v + Arborchem TG Oil 95% v/v; ACP 120OD-M 10% v/v + Arborchem TG Oil 90% v/v; ACP 120OD-M 20%

v/v + Arborchem TG Oil 80% v/v; Method 240SL 2.5% v/v + Arborchem TG Oil 97.5% v/v; Method 240SL 5% v/v + Arborchem TG Oil 95% v/v; Method 240SL 10% v/v + Arborchem TG Oil 90% v/v; and Garlon 4 25% v/v + Arborchem TG Oil 75% v/v. The total volume mixed for each treatment was 300 milliliters.

On November 12, the air temperature was 46°F, air speed 5-10 MPH, clear skies, and soil temperature at 0-,1-,3-,6-inches was 50, 50, 52, and 52°F, respectively. The treatments were pre-mixed and applied with a CO_2-powered backpack sprayer with an ULV (ultra-low volume) wand and an adjustable cone spraying systems 5500-Y3 tip. Each tree was sprayed until wet but not to the point of runoff and evenly around the trunk from the soil line up to approximately 18 inches. During the applications, we noticed issues with the spray pattern for treatments 8, 9, and 10: Method 240SL 2.5% v/v + Arborchem TG Oil 97.5% v/v; Method 240SL 5% v/v + Arborchem TG Oil 95% v/v; Method 240SL 10% v/v + Arborchem TG Oil 90% v/v, respectively. At the start of applying treatments 8, 9, and 10 the spray pattern was coarse droplets but as we continued treating trees, about halfway through the treatments, the spray pattern became a small stream due to gelling of the basal bark mix. We did our best to evenly apply the mix despite the small stream pattern. Gelling did not occur with any other mixes.

The winter was typical for central Pennsylvania, followed by a slightly cool start to spring. Throughout mid to late spring and into the beginning of summer, the site experienced above average rainfall. However, from August through mid-September the site experienced drought conditions causing some tree species to change color and drop leaves earlier than normal, including black birch. The experiment was rated for percent living leaf canopy on June 3 (203 days after treatment, DAT), July 30 (260 DAT), and August 28, 2025 (289 DAT). During the initial rating on June 3, we determined that plant #1, 3, and 4 were red maple plus plant # 10 and 44 were not located so those were not included in the analysis. As a result, treatments 2, 3, 6, 7, and 9 have 8 replications instead of nine. On September 18, black birch was in full fall leaf color, so no further ratings were conducted. All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

On June 3 (203 DAT), percent living leaf canopy was rated and ranged from 83.1 to 95.8 with no statistical difference among treatments, including the untreated check. By July 30 (260 DAT), percent living leaf canopy (LLC) decreased for most treatments. Garlon 4 25% v/v + Arborchem TG Oil 75% v/v showed 64.4% LLC and was the only treatment significantly different from the untreated. Seven herbicide treatments (ACP 120OD-V 5% v/v + Arborchem TG Oil 95% v/v; ACP 120OD-V 10% v/v + Arborchem TG Oil 90% v/v; ACP 120OD-M 5% v/v + Arborchem TG Oil 95% v/v; ACP 120OD-M 10% v/v + Arborchem TG Oil 90% v/v; ACP 120OD-M 20% v/v + Arborchem TG Oil 80% v/v; Method 240SL 5% v/v + Arborchem TG Oil 95% v/v; Method 240SL 10% v/v + Arborchem TG Oil 90% v/v) were statistically similar to Garlon 4 25% v/v + Arborchem TG Oil 75% v/v and the untreated, while the remaining 2 herbicide treatments (ACP 120OD-V 20% v/v + Arborchem TG Oil 80% v/v and Method 240SL 2.5% v/v + Arborchem TG Oil 97.5% v/v) were statistically similar to the untreated. The final rating on August 28 (289 DAT), showed Garlon 4 25% v/v + Arborchem TG Oil 75% v/v with

43% LLC the lowest for this experiment. Of the aminocyclopyrachlor treatments only 3 showed less than 80% LLC including: ACP 120OD-M 5% v/v + Arborchem TG Oil 95% v/v (79.9), ACP 120OD-M 20% v/v + Arborchem TG Oil 80% v/v (79.4), and Method 240SL 10% v/v + Arborchem TG Oil 90% v/v (62.2). In comparing the different rates of the ACP 120OD-V formulation, all were similar and ranged from 80.9 to 82.8 LLC. Also comparing the different rates of the ACP 120OD-M formulation, all were similar and ranged from 79.4 to 86.1 LLC. Method 240SL 10% v/v + Arborchem TG Oil 90% v/v showed the least LLC at 62.2% of the 3 Method 240SL rates, and again not statistically different and ranging from 62.2 to 91.7 LLC.

CONCLUSIONS

Garlon 4 25% v/v + Arborchem TG Oil 75% v/v showed the lowest percent living leaf canopy on black birch of the treatments applied for this experiment. All herbicide treatments were statistically similar to the untreated, except Garlon 4 25%v/v + Arborchem TG Oil 75%v/v. Increasing the concentration of Method 240SL reduced percent living leaf canopy.

MANAGEMENT IMPLICATIONS

Black birch is a difficult to control tree species, however, Garlon 4 25%v/v + Arborchem TG Oil 75%v/v treatment was suspected to provide better control than results indicated. Application timing may be a factor in reduced control. Future research should evaluate similar treatments applied during the spring and summer to determine if the results vary based on season. In addition, other tree species like red maple or poplar, as well as other pioneering tree species should be targeted. During the applications of the 3 treatments containing Method 240SL + Arborchem TG Oil, physical incompatibilities were observed during the application. Initially, the spray pattern was coarse droplets but as we continued treating trees the spray pattern gelled to the point where the spray pattern was a small stream. Caution should be exercised if using Method 240SL for basal bark applications as there are label precautions on incompatibility issues with some basal oils.

Table 1. Percent living leaf canopy of black birch *(Betula lenta)*. The experiment was rated for percent living leaf canopy on June 3 (203 days after treatment, DAT), July 30 (260 DAT) & August 28, 2025 (289 DAT). Treatments were applied on November 12, 2024. Treatments 2, 3, 6, 7, and 9 are the mean of 8 replications while the others are the mean of 9 replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Product	Rate % v/v	% Living Leaf Canopy 6/3/25 203 DAT	% Living Leaf Canopy 7/30/25 260 DAT	% Living Leaf Canopy 8/28/25 289 DAT
1	Untreated	--	90.7	94.3 b	93 b
2	ACP 120OD-V Arborchem TG Oil	5 95	92	83.9 ab	82.8 ab
3	ACP 120OD-V Arborchem TG Oil	10 90	89.6	84.5 ab	80.9 ab
4	ACP 120OD-V Arborchem TG Oil	20 80	91.6	92.2 b	82.2 ab
5	ACP 120OD-M Arborchem TG Oil	5 95	90.9	86.3 ab	79.9 ab
6	ACP 120OD-M Arborchem TG Oil	10 90	91.3	91.6 ab	86.1 b
7	ACP 120OD-M Arborchem TG Oil	20 80	89.6	91.1 ab	79.4 ab
8	Method 240SL Arborchem TG Oil	2.5 97.5	95.8	95.8 b	91.7 b
9	Method 240SL Arborchem TG Oil	5 95	91.5	88.3 ab	82.1 ab
10	Method 240SL Arborchem TG Oil	10 90	90.3	85.6 ab	62.2 ab
11	Garlon 4 Arborchem TG Oil	25 75	83.1	64.4 a	43 a
			n.s.		

EVALUATION OF HERBICIDE MIXES FOR THE CONTROL OF PHRAGMITES (*Phragmites australis)*

Herbicide trade and common names: Polaris *(imazapyr),* RoundUp Custom ATU *(glyphosate),* Vastlan *(triclopyr choline)*

Plant common and scientific name: phragmites *(Phragmites australis)*

ABSTRACT

Phragmites *(Phragmites australis)* is a tall grass and common problematic species of roadsides. It typically inhabits moist or water saturated environments. An experiment was established on August 27, 2025, to evaluate the efficacy of various herbicide treatments for controlling phragmites. Treatments included Polaris at 64 oz/ac, RoundUp Custom ATU at 96 oz/ac, Polaris at 48 oz/ac + RoundUp Custom ATU at 48 oz/ac, Polaris at 64 oz/ac + RoundUp Custom ATU at 96 oz/ac, and Vastlan at 128 oz/ac. One month after treatment, mixes containing Roundup Custom ATU had the lowest percent phragmites cover ranging from 18.33 to 25 percent.

INTRODUCTION

Phragmites *(Phragmites australis),* is an invasive species commonly found on roadsides and medians in areas with adequate amounts of water present throughout the year like drainage basins and ditches. It is a perennial, cool season grass that can spread vegetatively through rhizomes forming large, dense stands attaining heights of 10-15 feet. This dense network of rhizomes makes phragmites a difficult plant to control as herbicides may kill aboveground shoots but fail to kill the root system allowing phragmites to reestablish. Also, these dense stands can rapidly take over an entire area like a drainage basin forming a monoculture and outcompeting desirable vegetation. The purpose of this experiment was to determine what herbicide products and mixes that include aquatic labeling most effectively control phragmites.

MATERIALS AND METHODS

An experiment was sprayed on August 27, 2025, to evaluate the efficacy of different herbicide products and mixes at controlling phragmites. First, the phragmites inside the plots were cut in June, 2 months prior to the herbicide application. Cutting the phragmites was meant to weaken the plant by forcing it to produce more shoots thereby depleting the energy stores in its root system. Cutting the phragmites also makes applying the herbicide easier since the regrowth is shorter. The herbicide application was done later in the summer when the plant is moving sugars down to its root system for storage. Applying herbicides later in the growing season is generally more effective because plants are actively transporting sugars down to their roots for storage, which allows the herbicide to move with this flow and reach the root system, resulting in more complete and long-lasting control of the plant.

The treatments included Polaris at 64 oz/ac, RoundUp Custom ATU at 96 oz/ac, Polaris at 48 oz/ac + RoundUp Custom ATU at 48 oz/ac, Polaris at 64 oz/ac + RoundUp Custom ATU at

96 oz/ac, and Vastlan at 128 oz/ac. Vastlan is not commonly used to control phragmites, however phragmites was listed on the label as a controlled weed species, therefore it was included with the more typical herbicides to determine its effectiveness.[15] On August 27, the air temperature was 64°F, air speed 5-10 MPH, clear skies, and soil temperature at 0-,1-,3-,6-inches was 65, 64, 65, and 65°F, respectively. The treatments were pre-mixed and applied at an estimated 35 gallons per acre with a CO_2-powered backpack sprayer equipped with a GunJet 30 spray gun with one X6 adjustable cone nozzle operating at 32 PSI (pounds per square inch). Treatments were visually rated for percent injury where 0 = no injury and 100 = complete injury on September 10, 2025, 14 days after treatment (DAT) and phragmites cover where 0 = no phragmites cover and 100 = complete phragmites cover on September 29, 2025, 33 DAT. All data was subjected to analysis of variance and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

On September 10, percent injury to phragmites ranged from 11.67 to 55 with the untreated check at 0.67. The treatment with the highest injury was Polaris at 64 oz/ac + RoundUp Custom ATU at 96 oz/ac with 55 percent. Other treatments with a statistically similar percent injury were RoundUp Custom ATU at 96 oz/ac (50 percent) and Polaris at 48 oz/ac + RoundUp Custom ATU at 48 oz/ac (41.67 percent). The treatments with the lowest percent injury and statistically similar to the untreated check were Vastlan at 128 oz/ac (18.33 percent) and Polaris at 64 oz/ac (11.67 percent). All three treatments that had the highest percent injury included RoundUp Custom ATU and were statistically similar to each other. Polaris at 64 oz/ac resulted in the lowest percent injury (11.67%), indicating that RoundUp Custom ATU was likely responsible for the higher injury observed when both herbicides were included in the mixture.

On September 29 phragmites cover was rated and ranged from 18.33 to 75 percent with the untreated check at 96.67 percent. The treatments with the lowest percent cover were Polaris at 64 oz/ac + RoundUp Custom ATU at 96 oz/ac (18.3 percent), Polaris at 48 oz/ac + RoundUp Custom ATU at 48 oz/ac (21.67 percent) and RoundUp Custom ATU at 96 oz/ac (25 percent). All three treatments were statistically similar. Vastlan at 128 oz/ac had a percent cover of 43.33. Polaris at 64 oz/ac had the highest percent cover with 75. All treatments were statistically different from the untreated check which had a phragmites cover of 96.67 percent. These results substantiated previous results from the percent injury rating taken two weeks prior, with the treatments containing RoundUp Custom ATU being the most effective, while the treatment with Polaris by itself being the least effective. One explanation for the better performance by RoundUp Custom ATU is that glyphosate produces more immediate results with a quicker burndown while Polaris, which uses imazapyr as its active ingredient, takes longer to see its effects on the plants.[16] Both ratings were taken shortly after application so ratings in the following year may show better control of the phragmites from Polaris.

[15] Corteva Agriscience. Dow AgroSciences LLC Vastlan label. https://www.agrian.com/pdfs/Vastlan_Label1d.pdf
[16] Hudek et Al. 2021. Comparative Analyses of Glyphosate Alternative Weed Management Strategies on Plant Coverage, Soil and Soil Biota. Sustainability. 13(20). pp. 17.

CONCLUSION

Polaris at 64 oz/ac + RoundUp Custom ATU at 96 oz/ac showed the lowest percent phragmites cover. RoundUp Custom ATU at 96 oz/ac, and Polaris at 48 oz/ac + RoundUp Custom ATU at 48 oz/ac were also effective and statistically similar. Vastlan at 128 oz/ac was in its own statistical group and less effective than the treatments with RoundUp Custom ATU while Polaris at 64 oz/ac was also in its own statistical group and was the least effective.

MANAGEMENT IMPLICATIONS

Currently, treatments with RoundUp Custom ATU have controlled phragmites most effectively. However, the imazapyr in Polaris takes longer to affect the plant.[17] It is too early to determine the long-term control of each treatment. Cutting the phragmites earlier in the summer to weaken the plant and applying the herbicide treatment later in the summer, like in August, should offer benefits by allowing the herbicide to travel into the roots along with the sugars. Cutting also aids in the herbicide application as the plants are shorter and more manageable to effectively target. Future research could be done to see if a second herbicide application is needed for complete control the following year. Also, mowing the phragmites twice before applying herbicides may provide greater control due to further draining the energy stored in the plant's extensive root system.

[17] Hudek et Al. 2021. Comparative Analyses of Glyphosate Alternative Weed Management Strategies on Plant Coverage, Soil and Soil Biota. Sustainability. 13(20). pp. 17.

Table 1. Percent injury of phragmites *(Phragmites australis)*. Plants were cut 2 months prior to the herbicide treatments applied on August 27, 2025. The experiment was visually rated for percent injury where 0 = no injury to 100 = complete injury on September 10, 2025, 14 DAT (days after treatment) and percent phragmites cover where 0 = 0% phragmites cover to 100 = 100% phragmites cover on September 29, 2025, 33 DAT. All treatments included CWC 90 at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letters are not significantly different at $p \leq 0.05$.

Treatment	Product	Rate oz/acre	% phragmites injury 9/10/25 14 DAT	% phragmites cover 9/29/25 33 DAT
1	Untreated	--	0.67a	96.67d
2	Polaris	64	11.67ab	75c
3	RoundUp Custom ATU	96	50bc	25a
4	Polaris RoundUp Custom ATU	48 48	41.67bc	21.67a
5	Polaris RoundUp Custom ATU	64 96	55c	18.33a
6	Vastlan	128	18.33abc	43.33b

EVALUATION OF PLANT GROWTH REGULATORS AND HERBICIDE MIXES TO MANAGE TURFGRASS NEAR CABLE GUIDERAILS

Herbicide trade and common names: Plateau *(imazapic),* Pendulum Aquacap *(pendimethalin),* Prodiamine WDG *(prodiamine)*, Game Up *(trinexapac-ethyl)*, Escort XP *(metsulfuron-methyl)*, TerraVue *(aminopyralid + florpyrauxifen-benzyl),* Freelexx *(2,4-D choline salt)*

Plant common and scientific names: tall fescue *(Schedonorus arundinaceus)*, fine fescue *(Festuca spp.)*, Kentucky bluegrass *(Poa pratensis)*

ABSTRACT

Plant growth regulator (PGR) applications are used to suppress tall fescue seedheads and reduce turfgrass growth. PGR's can reduce mowing cycles and manage turfgrass growth in roadside areas such as along cable guiderails, slopes behind guiderails, difficult to mow slopes, and larger turfgrass areas seeded in tall fescue. Effective PGR treatments may eliminate one mowing cycle. The purpose of this experiment was to evaluate the effectiveness of Game Up versus Plateau as a PGR, to determine the effectiveness of a second application of Game Up later in the growing season, and to evaluate Pendulum Aquacap and Prodiamine for effectiveness in preventing the germination of summer annual grasses. There were eleven initial PGR treatments with six of those receiving a second PGR application. The first applications included the following herbicide mixes: Plateau at 2 oz/acre + Pendulum Aquacap at 64 oz/ac, Plateau at 2 oz/ac + Prodiamine at 32 oz/ac, Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac, Plateau at 2 oz/ac + Prodiamine at 32 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac, Plateau at 2 oz/ac + Freelexx at 64 oz/ac, Plateau at 2 oz/ac + Escort XP at 0.2 oz/ac, Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac, Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac, Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac, Plateau at 4 oz/ac + Prodiamine at 32 oz/ac, and Plateau at 4 oz/ac + TerraVue at 2.5 oz/ac. The initial application was applied on April 22, 2025. Six treatments received a second herbicide application of Game Up at 44 oz/ac on May 30. By June 11, most treatments showed an increase in percent total seedhead cover ranging from 5.75 to 77.5 percent for the treated plots while the untreated plot was 93.75 percent. Plateau at 4 oz/ac + Prodiamine at 32 oz/ac resulted in the lowest total seedhead cover at 5.75 percent. The other treatment with less than 10 percent total seedhead cover was Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac at 9.75 percent. Plateau was more effective than Game Up as a PGR. Herbicide treatments with Plateau showed much lower tall fescue seedhead cover than herbicide treatments using only Game Up. Prodiamine and Escort XP were used as preemergence herbicides. TerraVue and Freelexx were used to reduce broadleaf weed cover.

INTRODUCTION

Common grass species along Pennsylvania roadsides are tall fescue, Kentucky bluegrass, and fine fescues. The two dominant fine fescue species include creeping red fescue and hard fescue. Tall fescue, however, is the primary target of plant growth regulator (PGR) applications as their seedheads are normally taller and more readily obstruct views or hazards in comparison to fine fescue and Kentucky bluegrass. PGR applications are typically made to areas near cable guiderails, slopes behind guiderails, difficult to mow slopes, and larger turfgrass areas. The purpose of these treatments is to suppress seedheads and reduce turf growth to lessen mowing.

PGR applications are generally applied once per year in the springtime. For the application to be effective, timing the application properly is critical. PGR applications need to be timed at the early boot growth stage of tall fescue. The boot stage is when the seedhead starts to swell at the base of the grass stem. Physical observation in the field is needed to track the boot stage. In addition, tracking growing degree days (GDD) is a helpful way to provide insight into the developmental stage of the tall fescue. Previous research by the project has found seedheads in the stem of tall fescue at around 100 GDD, however they were not yet swollen. At 180 GDD the tall fescue was in the actual boot growth stage. Monitoring GDD's can be used to help time PGR applications. A typical PGR mix on roadsides would include Plateau at 2 oz/ac and a broadleaf weed (BLW) herbicide. This mix will both suppress seedheads of the tall fescue while providing control of broadleaf weeds.

While the normal procedure of applying a single PGR application is effective at suppressing seedheads and delaying a mowing cycle, this experiment seeks to see how effective a second PGR application compares to a single PGR application in both suppressing seedheads and maintaining low turf height. If a second application is seen to effectively manage turf for a longer time period, a further reduction in mowing cycles could be achieved. Another aspect the experiment evaluated was the addition of preemergence herbicides in the first application to control summer annual grasses like crabgrass, foxtails, or barnyard grass. The preemergence herbicides evaluated were Pendulum Aquacap and Prodiamine. The first application targeted seedhead suppression, control of BLWs, and suppressing seed germination of summer annual grasses using multiple components including a PGR, a BLW herbicide, and a preemergence herbicide. The second application targeted turfgrass growth with an additional PGR application. Another purpose of the experiment was comparing the effectiveness of the PGR Game Up with Plateau. Plateau used as a "PGR" causes injury to tall fescue resulting in reduced growth and seedhead suppression whereas, Game Up suppresses cell elongation.

MATERIALS AND METHODS

The experiment was located along a cable guiderail on the I-99 median approximately 2 miles south of Tyrone, PA. It was arranged as a randomized complete block design with four replications and a plot size of 20 feet by 6 feet. There were 11 total herbicide treatments. Five herbicide treatments had only a single application while the remaining six treatments had a second application approximately four weeks after the first. The first application included Plateau at 2 oz/acre + Pendulum Aquacap at 64 oz/ac, Plateau at 2 oz/ac + Prodiamine at 32 oz/ac, Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac, Plateau at 2 oz/ac + Prodiamine at 32 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac, Plateau at 2 oz/ac + Freelexx at 64 oz/ac, Plateau at 2 oz/ac + Escort XP at 0.2 oz/ac, Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac, Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac, Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac, Plateau at 4 oz/ac + Prodiamine at 32 oz/ac, and Plateau at 4 oz/ac + TerraVue at 2.5 oz/ac. For the second herbicide application Game Up at 44 oz/ac was used. The six treatments that then received a second PGR application were Plateau at 2 oz/ac + Prodiamine at 32 oz/ac, Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac, Plateau at 2 oz/ac + Freelexx at 64 oz/ac, Plateau at 2 oz/ac + Escort XP at 0.2 oz/ac, Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac, and Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac. The first herbicide application was applied on April 22, 2025 (108 GDD). For treatments that received a second application, it was applied on May 30, 2025. Treatments were pre-measured, mixed, and applied using a CO_2-powered backpack sprayer

equipped with a 6-foot boom and four 8004 nozzles operating at 32 PSI (pounds per square inch) and delivering 35 gallons per acre. Weather on April 22 was partly sunny, winds at 5-10 MPH, 58% relative humidity, and an air temperature of 68°F. Local rain events occurred on April 26, 27, 30, May 2, 2024, with 0.35", 0.45", 0.05", and 0.75" respectively, according to https://www.weather.gov/wrh/Climate?wfo=ctp. The nearest weather station was at Tyrone, PA. The weather at the time of the second application on May 30, was partly sunny, winds at 0-5 MPH, 67% relative humidity, and an air temperature of 65°F.

The plots were visually rated for percent turf cover, percent tall fescue cover, percent Kentucky bluegrass + fine fescue cover, and percent BLW cover on April 21, 2025, prior to the first herbicide application. Average turfgrass height was recorded on April 28, May 6, May 15, May 29, June 11, June 24, July 29, and September 2. Each plot contained three equally spaced subplots for measuring turfgrass height. Percent tall fescue seedhead cover, Kentucky bluegrass and fine fescue seedhead cover, and total seedhead cover was rated on May 6, May 15, May 29, June 11, June 24, and July 29. Percent broadleaf weed cover was rated on April 21, May 6, May 15, May 29, June 11, June 24, and July 29. Percent annual grass cover was rated on July 29 and September 2. Phytotoxicity was visually rated on April 30, May 6, May 15, May 29, June 11, June 24, and July 29. Phytotoxicity was rated to see if certain herbicide mixes, particularly those with higher rates of Plateau, would cause injury to the turf. Only a representative number of ratings and their data are reported to best reflect the results of the trial. All data were subjected to analysis of variance and when F-tests were significant ($p<0.05$), treatment means were compared using Tukey's separation test.

RESULTS AND DISCUSSION

Initial percent cover for tall fescue, Kentucky bluegrass + fine fescue, and BLW (Table 1) was rated on April 21, 2025, prior to the first herbicide application. Total turfgrass cover ranged from 93.75 to 96.69 percent with no significant difference among treatments. Tall fescue cover ranged from 60.69-66.25 percent with no significant difference among treatments. Kentucky bluegrass and fine fescue cover ranged from 30-35.25 percent with no significant difference among treatments. Broadleaf weed cover ranged from 0-0.13 percent with no significant difference among treatments. The site had well established turf cover with minimal to no broadleaf weed cover. Also, tall fescue had a statistically similar distribution throughout the site allowing for a good comparison of seedhead suppression.

On May 15, 23 DAT, the plots were visually rated for percent tall fescue seedhead cover (Table 2), Kentucky bluegrass seedhead cover, and total seedhead cover. The total seedhead cover ranged from 7.5 to 33.75 percent for herbicide treatments and 81.25 percent for the untreated check. Based on percent total seedhead cover, all herbicide treatments were significantly different from the untreated check. Tall fescue seedhead cover ranged from 0 to 0.75 percent for the herbicide treatments with the untreated check at 35 percent. All herbicide treatments were statistically similar to one another with a percent tall fescue seedhead cover below 1 percent.

Kentucky Bluegrass and fine fescue seedhead cover ranged from 7.38 to 33.66 percent for the herbicide treatments with the majority being Kentucky bluegrass. Kentucky bluegrass seedhead had already emerged prior to the date of application on April 22, so control of the seedheads from the PGR treatments was ineffective.

On June 11, 50 DAT (Table 3), the plots were visually rated for percent tall fescue seedhead cover, Kentucky bluegrass seedhead cover, and total seedhead cover. At this date the second application of PGR, which is Game Up at 44 oz/ac, had been applied to 6 treatments (treatments 3,4,6,7,9, and 10). The purpose of the second application was to continue to suppress turfgrass growth. Tall fescue seedhead cover ranged from 1 percent to 45 percent for the treated plots and 62.5 percent for the untreated check. Plateau at 4 oz/ac + Prodiamine at 32 oz/ac resulted in the lowest tall fescue seedhead cover at 1 percent. While not statistically different in percent tall fescue seedhead cover from the other Plateau treatments, using Plateau at 4 oz/ac could be the reason for such a low result. Two herbicide mixes used Plateau at 4 oz/ac instead of Plateau at 2 oz/ac and they ranged from 1 to 2.75 percent tall fescue seedhead cover. Raising the dosage of Plateau to 4 oz/ac did result in low tall fescue seedhead cover, however not significantly from treatments with Plateau at 2 oz/ac. Another treatment with less than 2 percent tall fescue seedhead cover was Plateau at 2 oz/ac + Prodiamine at 32 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac.

Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac (treatment 8) was the highest treatment for tall fescue seedhead cover at 45 percent while the other Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac (treatment 7) was 38.75%. Both treatments that used Game Up + Escort XP as the initial PGR showed significantly higher percent tall fescue seed head cover compared to initial treatments that included Plateau. The Game Up label states that at label rates Game Up provides only partial seedhead suppression of Kentucky bluegrass and tall fescue. In contrast the highest percent tall fescue seedhead cover from an application using Plateau as the PGR was Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac at 5.25 percent. All treatments with Plateau were statistically similar for percent tall fescue cover with or without the addition of Game Up.

Turfgrass height was measured throughout the growing season (Table 4). Measurements were taken in April, May, June, July, and September and data presented are the mean of four replications. On April 28 (6 DAT) the first turfgrass height measurements were taken. Turfgrass height ranged from 9.17 to 11 in. with the untreated check at 9 in. of height. All treatments were statistically similar in height. On May 15, 23 days after the first treatment, turfgrass heights ranged from 9.75 to 14.25 in. with the untreated check at 23.25 in. All treatments were statistically different from the untreated check. By June 11, 50 DAT, the treatment with the lowest turfgrass height was Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac at 12.75 in. The two treatments with Game Up as the sole PGR had the highest turf heights in large part due to their inability to suppress seedheads. Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac had a turf height of 23.75 in. and the second identical Game Up herbicide treatment that included a second application of Game Up at 44 oz/ac had a turfgrass height of 22.33 in. Both herbicide treatments with Plateau at 4 oz/ac (Plateau at 4 oz/ac + Prodiamine at 32 oz/ac and Plateau at 4 oz/ac + TerraVue at 2.85 oz/ac) had a turf height of 13.67 in. which was statistically similar to herbicide treatments with Plateau at 2 oz/ac. Therefore, raising the rates of Plateau to 4 oz/ac doesn't seem to improve its efficacy as a PGR. By the final turfgrass height rating on September 2, 133 DAT, all treatments and the untreated check were statistically similar likely due to the absence of seedheads by that time.

Including a second PGR application in May appears to have a slight effect on turfgrass height but not enough to recommend the practice. For example, by June 11, the treatment with the lowest turfgrass height was Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac, along with a second treatment of Game Up at 44oz/ac at

12.75 in., however the treatment was still statistically similar to all treatments that included Plateau as the primary PGR, even if they didn't have the second PGR application of Game Up. Also, the only treatments that shared an identical first application mix was Game Up at 44 oz/ac + Escort XP at 0.2 oz/ac and the treatment that received a second Game Up application was only marginally better with no statistical difference (22.33 in. versus 23.75 in.).

Phytotoxicity to turfgrass was measured in April, May, and June (Table 5). Phytotoxicity was measured due to the concern that certain herbicide treatments, particularly treatments with higher rates of Plateau at 4 oz/ac, could injure the turf and cause an unsightly appearance. Phytotoxicity was visually rated on a scale from 0-10 where 0 was completely dead turf and 10 was healthy, vibrantly green turf. On April 30, the first phytotoxicity rating was taken. The phytotoxicity ranged from 7.75 to 9 with the untreated check plots at 9.75. Two treatments shared the lowest rating of 7.75 and they were Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + Game Up at 44 oz/ac + TerraVue at 2.85 oz/ac and Plateau at 4 oz/ac + TerraVue at 2.5 oz/ac. However, both treatments were still statistically similar to the other treatments. Overall, phytotoxicity data did not vary much between ratings and by the final rating on June 24 all treatments and the untreated check plots were statistically similar. Therefore, differences in phytotoxicity of the herbicide treatments were not impactful enough to affect recommendations and using Plateau at 4 oz/ac did not appear to injure the turf in a significant way.

Percent BLW and annual grass cover can be found in Table 6. Percent broadleaf weed cover ranged from 0 to 0.13 prior to treatments. Percent broadleaf cover remained at zero or near zero for the rest of the experiment without ever having any statistical difference between treatments and the untreated check. Percent annual grass cover was rated on September 2 and ranged from 0 to 2.46 percent with no significant differences among treatments or the untreated check. Pendulum Aquacap has shown promise in previous experiments controlling annual grasses.[18] In this experiment there was no significant difference between the herbicide treatments or the untreated check. A possible explanation for this was that the PGR site didn't have much pressure from annual grasses as even the untreated check plots had only 2.13 percent cover by the final rating, 133 DAT. This would make it hard to determine differences from the herbicide treatments regarding annual grass control. However, treatments that included either preemergence herbicide Prodiamine or Pendulum Aquacap showed less than 0.5% annual grass cover.

CONCLUSIONS

PGR mixes that used Plateau as the PGR were more effective at reducing tall fescue seedheads than mixes that used Game Up. Plateau and Game Up in combination did not significantly impact tall fescue seedhead suppression compared to Plateau alone. Also, Plateau at 4 oz/ac did not significantly impact tall fescue seedhead suppression compared to Plateau at 2 oz/ac. Increasing the rates of Plateau to 4 oz/ac did not have a noticeable difference in phytotoxicity compared to Plateau at 2 oz/ac. Future research should evaluate if a third PGR application would be beneficial later in the season to suppress cool season grasses and evaluate other PGR products.

[18] Jodon et. Al. 2025. Applications of Plant Growth Regulators and Herbicides to Manage Turfgrass Near Cable Guiderails Roadside Management Research-2025 Report pp 37-49.

MANAGEMENT IMPLICATIONS

PGR mixes are applied along cable guiderails, slopes behind guiderails, difficult to mow slopes, or larger turfgrass areas. PGR treatments are meant to suppress seedheads and lessen grass growth in order to reduce mowing cycles or manage turf growth in difficult to mow areas. For the greatest effect, PGR applications need to be timed correctly for the greatest suppression of seedheads. Ideally, application of the PGR should be done prior to the boot stage of tall fescue. The boot stage is when the seedhead at the base of the stem is swollen. Scouting in the field is critical to timing the application. Tracking growing degree days (GDD) is helpful for timing a PGR application. Based on previous experience, tall fescue seedheads are found in the stems without being swollen around 100 GDDs. The seedheads become swollen around 180 GDDs. The application for this experiment was on April 22, 108 GDDs. Additional data on proper timing of PGR applications will continue to be collected in future PGR experiments.

Based on this experiment, Plateau at 2 oz/ac remains the optimum PGR treatment. PGR mixes can be adjusted depending on the site. For example, the site for this experiment did not have a large presence of BLW or annual grasses which is reflected in the lack of statistical difference between the untreated check and the various herbicide treatments. However based on prior experiments, herbicides like TerraVue at 2.85 oz/ac, Method 240SL at 8 oz/ac, Escort XP at 0.2 oz/ac, Freelexx at 64 oz/ac, or Triplet LO at 64 oz/ac can be added to effectively control BLWs.[19] Pendulum Aquacap at 64 oz/ac can be added to control annual grasses like foxtail, crabgrass, witchgrass, and others. A good PGR mix that will provide a variety of coverage is Plateau at 2 oz/ac + Pendulum Aquacap at 64 oz/ac + TerraVue at 2.85 oz/ac. Other BLW products like Method 240SL at 8 oz/ac or Freelexx at 64 or Triplet LO at 64 oz/ac could be substituted for TerraVue.

[19] Jodon et. Al. 2025. Applications of Plant Growth Regulators and Herbicides to Manage Turfgrass Near Cable Guiderails Roadside Management Research-2025 Report pp 37-49.

Table 1. Initial percent cover for tall fescue, Kentucky bluegrass (KBG) + fine fescue, total turfgrass, and broadleaf weeds. Plots were rated on April 21, 2025, prior to the 1st herbicide application on April 22, 2025. Values are the means of four replications. Column means followed by the same letter are not statistically different.

Treatment	Product	Rate oz/acre	% Tall Fescue Cover 4/21/25 0 DAT	% KBG + Fine Fescue Cover 4/21/25 0 DAT	% Turf Cover 4/21/25 0 DAT	% BLW Cover 4/21/25 0 DAT
1	Untreated	--	62.25	33.25	95.5	0
2	Plateau Pendulum Aquacap	2 64	64.44	30.44	94.88	0.13
3	Plateau Prodiamine	2 32	63.75	31.5	95	0
	GameUp	44				
4	Plateau Pendulum Aquacap	2 64	65	30.5	95.75	0
	GameUp	44				
5	Plateau Prodiamine Game Up TerraVue	2 32 44 2.85	62.75	32.5	95.25	0
6	Plateau Freelexx	2 64	63.75	30	93.75	0
	Game Up	44				
7	Plateau Escort XP	2 0.2	60.69	35.25	95.94	0.06
	Game Up	44				
8	Game Up Escort XP	44 0.2	66.25	30	96	0
9	Game Up Escort XP	44 0.2	65	31.69	96.69	0.06
	Game Up	44				
10	Plateau Pendulum Aquacap Game Up TerraVue	2 64 44 2.85	61	33.25	94.25	0
	Game Up	44				
11	Plateau Prodiamine	4 32	63.75	32	95.75	0
12	Plateau TerraVue	4 2.5	63.75	32.25	96	0
			n.s	n.s	n.s	n.s

Table 2. Percent seedhead cover for tall fescue, Kentucky bluegrass and fine fescue, and total seedhead cover rated on May 15, 2025, 23 days after treatment (DAT). The 1st herbicide application was applied on April 22, 2025. Values are the mean of four replications. Column means followed by the same letter are not statistically different.

Treatment	Product	Rate oz/acre	% Tall Fescue Seed Head Cover 5/15/25 23 DAT	% KBG and Fine Fescue Seed Head Cover 5/15/25 23 DAT	% Total Seed Head Cover 5/15/25 23 DAT
1	Untreated	--	35b	46.25d	81.25d
2	Plateau	2	0.03a	16.73abc	16.75abc
	Pendulum Aquacap	64			
3	Plateau	2	0.21a	9.91a	14.5ab
	Prodiamine	32			
	Game Up	44			
4	Plateau	2	0.09a	19.66abc	19.75abc
	Pendulum Aquacap	64			
	Game Up	44			
5	Plateau	2	0.03a	33.66cd	33.75c
	Prodiamine	32			
	Game Up	44			
	TerraVue	2.85			
6	Plateau	2	0.13a	7.38a	7.5a
	Freelexx	64			
	Game Up	44			
7	Plateau	2	0.25a	14ab	14.25ab
	Escort XP	0.2			
	Game Up	44			
8	Game Up	44	0.38a	28.38bcd	28.75bc
	Escort XP	0.2			
9	Game Up	44	0.4a	20.35abc	20.75abc
	Escort XP	0.2			
	Game Up	44			
10	Plateau	2	0a	7.94a	8a
	Pendulum Aquacap	64			
	Game Up	44			
	TerraVue	2.85			
	Game Up	44			
11	Plateau	4	0.75a	9.25a	10ab
	Prodiamine	32			
12	Plateau	4	0.25a	18abc	18.25abc
	TerraVue	2.5			

Table 3. Percent tall fescue seedhead cover, Kentucky bluegrass and fine fescue seedhead cover, and total seedhead cover rated on June 11, 2025, 50 days after treatment (DAT). The 1st herbicide application was applied on April 22, 2025, and the 2nd on May 30, 2025. Values are the mean of four replications. Column means followed by the same letter are not statistically different.

Treatment	Product	Rate oz/acre	% Tall Fescue Seed Head Cover 6/11/25 50 DAT	% KBG and Fine Fescue Seed Head Cover 6/11/25 50 DAT	% Total Seed Head Cover 6/11/25 50 DAT
1	Untreated	--	62.5c	32.5c	93.75d
2	Plateau Pendulum Aquacap	2 64	5.25a	16.75abc	22ab
3	Plateau Prodiamine Game Up	2 32 44	5a	14.75abc	20ab
4	Plateau Pendulum Aquacap Game Up	2 64 44	3.25a	24.25abc	27.5b
5	Plateau Prodiamine Game Up TerraVue	2 32 44 2.85	1.75a	27.25bc	29.25b
6	Plateau Freelexx Game Up	2 64 44	4a	6.75ab	10.75ab
7	Plateau Escort XP Game Up	2 0.2 44	4.75a	16.5abc	21.25ab
8	Game Up Escort XP	44 0.2	45b	32.5c	77.5cd
9	Game Up Escort XP Game Up	44 0.2 44	38.75b	33.75c	72.5c
10	Plateau Pendulum Aquacap Game Up TerraVue Game Up	2 64 44 2.85 44	3.06a	6.31ab	9.75ab
11	Plateau Prodiamine	4 32	1a	4.75a	5.75a
12	Plateau TerraVue	4 2.5	2.75a	13.5abc	16.25ab

Table 4. Average turfgrass height (inches) rated on April 28, May 6, May 15, May 29, June 11, June 24, July 29, September 2, 2025. The 1st herbicide treatments were applied on April 22, the 2nd herbicide treatments (Game Up 44 oz/ac -for select treatments) on May 30. Values are the means of four replications. Column means followed by the same letter are not statistically different.

Product	Rate oz/acre	Average Turf Height Inches 4/28/25 6 DAT	Average Turf Height Inches 5/6/25 14 DAT	Average Turf Height Inches 5/15/25 23 DAT	Average Turf Height Inches 5/29/25 37 DAT	Average Turf Height Inches 6/11/25 50 DAT	Average Turf Height Inches 6/24/25 63 DAT	Average Turf Height Inches 7/29/25 98 DAT	Average Turf Height Inches 9/2/25 133 DAT
Untreated	--	9	12.92b	23.25b	33.33d	37.17d	35.08e	18.08	11.83
Plateau Pendulum Aquacap	2 64	9.17	11.17ab	14.25a	15.67abc	17.08ab	18.33bc	15.17	13.67
Plateau Prodiamine Game Up	2 32 44	9.25	10.83ab	12.25a	14.5abc	15.5a	15.92ab	14.58	12.58
Plateau Pendulum Aquacap Game Up	2 64 44	9.25	9.92a	11.83a	13ab	14.5a	15.5ab	15.83	13.83
Plateau Prodiamine Game Up TerraVue	2 32 44 2.85	9.5	10.17a	12.75a	14.92abc	14.83a	17.58abc	14.83	14
Plateau Freelexx Game Up	2 64 44	9.67	10.25a	10.92a	12.58a	13.58a	13.25ab	14	12.5
Plateau Escort XP Game Up	2 0.2 44	10.08	8.75a	11.42a	13.08ab	14.42a	15.33ab	15.08	13.25
Game Up Escort XP	44 0.2	10.25	10.58ab	13.58a	18.17bc	23.75c	27.75d	17.42	12.42
Game Up Escort XP Game Up	44 0.2 44	10.5	10a	13.25a	18.58c	22.33bc	23.67cd	14	13
Plateau Pendulum Aquacap Game Up TerraVue Game Up	2 64 44 2.85 44	10.56	11ab	11.33a	10.67a	12.75a	11.83a	12.83	12.08
Plateau Prodiamine	4 32	10.83	10.67ab	9.75a	11.08a	13.67a	15ab	14.25	11.75
Plateau TerraVue	4 2.5	11	9.67a	10.5a	12.92ab	13.67a	16.25ab	14.75	13.5
		n.s						n.s	n.s

Table 5. Average phytotoxicity was rated on April 30, May 6, May 15, May 29, June 11, June 24, 2025, where 0 was completely dead turf and 10 was healthy, vibrantly green turf. The 1st herbicide treatments were applied on April 22, the 2nd herbicide treatments (Game Up 44 oz/ac - for select treatments) on May 30. Values are the means of four replications. Column means followed by the same letter are not statistically different.

Treatment	Product	Rate oz/acre	Phyto-toxicity 0-10 4/30/25 8 DAT	Phyto-toxicity 0-10 5/6/25 14 DAT	Phyto-toxicity 0-10 5/15/25 23 DAT	Phyto-toxicity 0-10 5/29/25 37 DAT	Phyto-toxicity 0-10 6/11/25 50 DAT	Phyto-toxicity 0-10 6/24/25 63 DAT
1	Untreated	--	9.75a	9.25	10b	9.88c	9.5b	8.75
2	Plateau Pendulum Aquacap	2 64	8.75ab	8.75	9ab	9bc	9ab	9.5
3	Plateau Prodiamine Game Up	2 32 44	8.75ab	9	8.5a	8.5ab	9ab	8.5
4	Plateau Pendulum Aquacap Game Up	2 64 44	8.75ab	9	8.75a	8.63ab	8.75ab	8.75
5	Plateau Prodiamine Game Up TerraVue	2 32 44 2.85	8.25a	8.75	9ab	8.63ab	9ab	9.25
6	Plateau Freelexx Game Up	2 64 44	9ab	9	8.25a	8.38ab	9ab	8.75
7	Plateau Escort XP Game Up	2 0.2 44	8.25a	8.75	8.25a	8.25ab	8.75ab	8.75
8	Game Up Escort XP	44 0.2	8.5ab	9	8.75a	8.63ab	9ab	9.25
9	Game Up Escort XP Game Up	44 0.2 44	8.5ab	9	8.75a	8.5ab	8.5a	9
10	Plateau Pendulum Aquacap Game Up TerraVue Game Up	2 64 44 2.85 44	7.75a	8.75	8.75a	8.38ab	9ab	8.75
11	Plateau Prodiamine	4 32	8a	8.75	8.13a	7.88a	9ab	9.5
12	Plateau TerraVue	4 2.5	7.75a	8.88	8.75a	8.5ab	9ab	9.25
				n.s				n.s

Table 6. Percent broadleaf weed (BLW) cover was rated on April 21, May 15, June 11, and July 29, 2025. Percent annual grass cover was rated on July 29 and September 2, 2025. The 1st herbicide treatments were applied on April 22, the 2nd herbicide treatments (Game Up 44 oz/ac -for select treatments) on May 30. Values from April through September are the mean of four replications. Column means followed by the same letter are not statistically different.

Treatment	Product	Rate oz/acre	% BLW Cover 4/21/25 0 DAT	% BLW Cover 5/15/25 23 DAT	% BLW Cover 6/11/25 50 DAT	% BLW Cover 7/29/25 98 DAT	% Annual Grass Weed Cover 7/29/25 98 DAT	% Annual Grass Weed Cover 9/2/25 133 DAT
1	Untreated	--	0	0.25	0.25	0.5	0.25	2.13
2	Plateau Pendulum Aquacap	2 64	0.13	0.38	1	0.5	0	0
3	Plateau Prodiamine GameUp	2 32 44	0	0	0	0	0.13	0.5
4	Plateau Pendulum Aquacap GameUp	2 64 44	0	0	0	0	0	0.13
5	Plateau Prodiamine Game Up TerraVue	2 32 44 2.85	0	0	0	0	0.25	0
6	Plateau Freelexx Game Up	2 64 44	0	0.13	0.5	0.06	0.38	2.46
7	Plateau Escort XP Game Up	2 0.2 44	0.06	0.06	0	0.25	1.5	3
8	Game Up Escort XP	44 0.2	0	0	0	0.13	0.13	1.69
9	Game Up Escort XP Game Up	44 0.2 44	0.06	0.19	0.25	0	0	1.44
10	Plateau Pendulum Aquacap Game Up TerraVue Game Up	2 64 44 2.85 44	0	0	0	0.25	0	0.18
11	Plateau Prodiamine	4 32	0	0.13	0	0	0.06	0.15
12	Plateau TerraVue	4 2.5	0	0	0	0.13	0	1.5
			n.s	n.s	n.s	n.s	n.s	n.s

DEMONSTRATION OF THREE BAREGROUND PROGRAMS WITH ALTERNATIVE SITE OF ACTION-YEAR THREE

Herbicide trade and common names: Arsenal Powerline *(imazapyr)*, Esplanade 200 SC *(indaziflam)*, Esplanade Sure *(indaziflam + rimsulfuron)*, Fusilade II *(fluaziflop-P)*, Hyvar XL (*bromacil*), Method 240SL *(aminocyclopyrachlor)*, Oust Extra *(sulfometuron-methyl + metsulfuron-methyl),* Pendulum Aquacap (*pendimethalin*), Piper EZ *(flumioxazin + pyroxasulfone)*, Plateau *(imazapic)*, Prodiamine 65 WDG *(prodiamine*), RoundUp Custom ATU *(glyphosate*), RoundUp Pro Concentrate *(glyphosate*), Segment II *(sethoxydim)*, TerraVue *(aminopyralid + florpyrauxifen-benzyl)*

INTRODUCTION

Bareground weed control is implemented on a roadside to ensure safe roads and travel corridors that allow water runoff during rainstorms, safe emergency stopping, and maintenance access to guiderails and signs. Most districts apply bareground mixes yearly along numbered routes and secondary roads; however, some may treat secondary roads every other year. A bareground mix has three components: a pre-emergence herbicide, a broad-spectrum residual herbicide, and a post emergence herbicide. Pre-emergence herbicides control weeds growing from seed. Broad-spectrum residual herbicides provide control of existing vegetation, as well as soil residual activity. Post emergence herbicides are effective at controlling actively growing, emerged weeds. The repeated use of the same bareground mix may lead to the development of herbicide resistant species and inability to control weeds. One strategy to manage resistance and help maintain herbicide effectiveness is to rotate the site of action of the pre-emergence, broad-spectrum residual, and post emergence herbicides of a bareground mix. Over the past few years, experiments have evaluated alternative bareground mixes that rotate the site of action (SOA) [20,21,22]. Using results from these previous experiments, alternative bareground mixes that rotate site of action were selected based on efficacy. Some bareground programs may take 4 years to rotate all SOA's of each component, while other bareground programs may take only 3 years. The goal of this demonstration is to evaluate 3 different bareground programs on a site to determine the efficacy of rotating different SOA's over multiple years.

MATERIALS AND METHODS

The demonstration was established beneath a guiderail along SR 350 near Bald Eagle, PA. First year treatments were applied on May 10, 2023 and second year treatments were applied on May 16, 2024 (Table 1). Treatments for the 2025 season included Prodiamine 65 WDG at 32 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac; Pendulum Aquacap at 128 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac; Plateau at 12 oz/ac + Esplanade Sure at 5 oz/ac + Oust Extra at 4 oz/ac + Segment II at 32 oz/ac; and an

[20] Jodon et.al 2022. Evaluation of Alternative Bareground Herbicide Mixes. Roadside Vegetation Management Research-2022 Report pp 31-41.
[21] Jodon et.al 2023. Evaluation of Alternative Bareground Herbicide Mixes. Roadside Vegetation Management Research-2023 Report pp 43-52.
[22] Jodon et.al 2023. Evaluation of Bareground Herbicide Mixes without Glyphosate. Roadside Vegetation Management Research-2023 Report pp 53-63.

untreated check. Induce, a non-ionic surfactant, was added to all herbicide treatments at 0.25% v/v. Plots were 80 by 4 feet in size. The herbicide treatments were applied on May 19, 2025. Treatments were pre-measured, mixed, and applied, using a CO_2 powered backpack sprayer equipped with one OC-06 nozzle operating at 32 PSI (pounds per square inch), and delivered 50 gallons per acre. Weather at the time of application was partly cloudy, winds at 5-10 MPH, 76% relative humidity, air temperature of 56°F and soil temperatures of 63°F, 65°F, 65°F, and 64°F, at 0-, 1-, 3-, and 6-inch depths, respectively. Local rain events occurred on May 19, 21, and 22, 2025, with 0.10", 0.05", and 1.70", respectively, according to https://www.weather.gov/wrh/Climate?wfo=ctp. The nearest weather station was in Tyrone, PA. Table 1 lists bareground program mixes used in years 1, 2, 3, and 4. Program 1 is untreated throughout the demonstration. Program 2 rotates SOA for each component over four years. Programs 3 and 4 rotate the SOA of each component over 3 years. It is important to rotate out of soil residual herbicides such as Method 240SL or TerraVue which have the same SOA, in this case SOA 4.

The experiment was visually rated for percent total vegetative cover on May 19, June 17, July 29, August 18, and September 17, 2025, 0, 29, 71, 91, and 121 days after treatment (DAT). Percent grass and broadleaf cover was visually rated on June 17, July 29, August 18, and September 17, 2025, 29, 71, 91, and 121 days after treatment (DAT). On October 10, 2025, a killing frost occurred at the site effectively ending the demonstration for the year.

RESULTS AND DISCUSSION

Prior to the initiation of this demonstration the guiderail site was treated yearly with a standard bareground mix (Method 240SL + Esplanade 200SC + Arsenal Powerline + RoundUp Pro Concentrate). The guiderail site was quite clean with minimal weed pressure. The first and second year herbicide treatments were applied May 10, 2023 and May 16, 2024, respectively. Results from 2023 and 2024 can be found in the appendix of this report (Appendix Tables 6-11) and the summary can be reviewed in the 2024 and 2025 annual report[23,24].

Initial total cover was rated prior to application on May 19 with the untreated plot at 65% while the treated plots ranged from 0.25% to 1% (Table 2). By June 17, 29 DAT percent total cover ranged from 0.15% for Plateau at 12 oz/ac + Esplanade Sure at 5 oz/ac + Oust Extra at 4 oz/ac + Segment II at 32 oz/ac to 0.25% for Pendulum Aquacap at 128 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac and Prodiamine 65 WDG at 32 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac. The untreated plot showed 60% total cover. Through July and August percent total vegetative cover increased for two herbicide treatments while, surprisingly one herbicide treatment showed a decrease in percent total vegetative cover. The untreated plot increased to 70% by 91 DAT. By the final rating on September 17, 121 DAT, Plateau at 12 oz/ac + Esplanade Sure at 5 oz/ac + Oust Extra at 4 oz/ac + Segment II at 32 oz/ac was 0.02%, Pendulum Aquacap at 128 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac was 0.51%, and Prodiamine 65 WDG at 32 oz/ac + Hyvar XL at 64 oz/ac + RoundUp

[23] Jodon et.al 2024. Demonstration of Three Bareground Programs with Alternative Site of Action-Year One. Roadside Vegetation Management Research-2024 Report pp 32-38

[24] Jodon et.al 2025. Demonstration of Three Bareground Programs with Alternative Site of Action-Year Two. Roadside Vegetation Management Research-2025 Report pp 50-59

Custom ATU at 64 oz/ac was 3% total vegetative cover. The untreated plots were 70% total vegetative cover.

Percent grass cover (Table 3) by September 17, 121 DAT showed the untreated plot at 35%, Prodiamine 65 WDG at 32 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac at 0.5%, Pendulum Aquacap at 128 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac at 0.01% and Plateau at 12 oz/ac + Esplanade Sure at 5 oz/ac + Oust Extra at 4 oz/ac + Segment II at 32 oz/ac at 0.01% grass cover. Percent broadleaf weed cover (Table 4) by September 17, 121 DAT for the untreated plot showed 35%, Prodiamine 65 WDG at 32 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac at 2.5%, Pendulum Aquacap at 128 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac showed 0.5% and Plateau at 12 oz/ac + Esplanade Sure at 5 oz/ac + Oust Extra at 4 oz/ac + Segment II at 32 oz/ac 0.01% broadleaf cover.

CONCLUSIONS

Based on a threshold of 5% or less total vegetative cover, all herbicide mixes evaluated: Prodiamine 65 WDG at 32 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac, Pendulum Aquacap at 128 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac and Plateau at 12 oz/ac + Esplanade Sure at 5 oz/ac + Oust Extra at 4 oz/ac + Segment II at 32 oz/ac were acceptable mixes. Programs 3 and 4 have rotated the sites of action for each component: pre-emergence, post emergence and broad spectrum residual, over the three year period (2023-2025). Both, program 3 and program 4, showed less than 1% total cover by the end of the third year and proved to be effective bareground programs at this site. Future work in 2026 will continue to evaluate the last bareground mix in bareground program 2 to determine the effectiveness of program 2 to the site after 4 years.

MANGEMENT IMPLICATIONS

Effective bareground mixes contain three components: pre-emergence, post emergence, and broad spectrum residual herbicides. Herbicide resistant weed species may develop from the repeated use of the same herbicides applied over time. A common practice is prescribing the same bareground mix and using this mix year after year setting up the potential development of herbicide resistance on roadsides. An approach to minimize the development of herbicide resistance is to rotate the site of action of each component.

This trial investigated several bareground programs that uses different bareground mixes and rotates the site of action of the pre-emergence, post emergence and broad spectrum residual herbicides over three or four years. Prior to the initiation of this project, the site was maintained with a standard bareground mix and was free of weeds. A standard bareground mix used in roadsides is Method 240SL 12 oz/ac + Esplanade 200SC 5 oz/ac +Arsenal Powerline 8 oz/ac + RoundUp 64 oz/ac. Program 3 and program 4 used different mixes over three years that rotated the site of action of the pre-emergence, post emergence and broad spectrum residual and showed very little (<1%) vegetative cover by the end of the third year. This is a small sample size but shows that alternative bareground mixes can be used in a program with good results for the site. However, sites are different and results may vary. An issue that may occur is greater weed cover

when using alternative bareground mixes. This may happen when bareground mixes use other pre-emergence herbicides in place of Esplanade or when glyphosate is rotated out of the mix.

The project will continue to evaluate bareground mixes that utilize a different site of action in pre-emergence, post emergence, and broad spectrum residual herbicides to gain experience and understanding of the mixes in different situations. From an operational perspective, it may be best to start a bareground program on a clean, weed free site and begin on a relatively small scale. There are various bareground mixes used in a program, not just the ones tested in this demonstration.

Table 1. Bareground Program 2, 3, & 4. Mixes that rotate site of action (SOA) each year. Program 1 (not shown) is untreated.

Program	Product	Rate oz/ac	SOA
2	Method 240SL	12	4
1st year	Esplanade 200 SC	5	29
	Arsenal Powerline	8	2
	RoundUp Pro Concentrate	64	9
2	Method 240SL	16	4
2nd year	Pendulum Aquacap	128	3
	Arsenal Powerline	8	2
	RoundUp Custom ATU	64	9
2	Prodiamine 65 WDG	32	3
3rd year	Hyvar XL	64	5
	RoundUp Custom ATU	64	9
2	TerraVue	5	4+4
4th year	Esplanade 200 SC	5	29
	Arsenal Powerline	8	2
	Fusilade II	24	1

Program	Product	Rate oz/ac	SOA
3	TerraVue	5	4+4
1st year	Esplanade 200 SC	5	29
	Arsenal Powerline	8	2
	Fusilade II	24	1
3	Method 240SL	12	4
2nd year	Piper EZ	20	14+15
	Arsenal Powerline	8	2
	RoundUp Custom ATU	64	9
3	Pendulum Aquacap	128	3
3rd year	Hyvar XL	64	5
	RoundUp Custom ATU	64	9

Program	Product	Rate oz/ac	SOA
4	Method 240SL	16	4
1st year	Prodiamine 65 WDG	32	3
	Arsenal Powerline	8	2
	RoundUp Pro Concentrate	64	9
4	Piper EZ	20	14+15
2nd year	Hyvar XL	64	5
	RoundUp Custom ATU	64	9
	Plateau	12	2
4	Esplanade Sure	5	29+2
3rd year	Oust Extra	4	2+2
	Segment II	32	1

Table 2. Percent total vegetative cover for herbicide treatments at 0, 29, 71, 91, & 121 days after treatment (DAT). The site was visually rated on May 19, June 17, July 29, August 18, & September 17, 2025. Treatments were applied May 19, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/ac	% Total Cover 5/19/25 0 DAT	% Total Cover 6/17/25 29 DAT	% Total Cover 7/29/25 71 DAT	% Total Cover 8/18/25 91 DAT	% Total Cover 9/17/25 121 DAT
1	Untreated	--	65	60	70	70	70
2	Prodiamine 65 WDG	32	0.5	0.25	1	1.1	3
3rd year	Hyvar XL	64					
	RoundUp Custom ATU	64					
3	Pendulum Aquacap	128	1	0.25	0.5	0.5	0.51
3rd year	Hyvar XL	64					
	RoundUp Custom ATU	64					
4	Plateau	12	0.25	0.15	0	0	0.02
3rd year	Esplanade Sure	5					
	Oust Extra	4					
	Segment II	32					

Table 3. Percent grass cover for herbicide treatments at 29, 71, 91, & 121 days after treatment (DAT). The site was visually rated on June 17, July 29, August 18, & September 17, 2025. Treatments were applied May 19, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/ac	% Grass Cover 6/17/25 29 DAT	% Grass Cover 7/29/25 71 DAT	% Grass Cover 8/18/25 91 DAT	% Grass Cover 9/17/25 121 DAT
1	Untreated	--	40	35	35	35
2	Prodiamine 65 WDG	32	0.01	0.05	0.1	0.5
3rd year	Hyvar XL	64				
	RoundUp Custom ATU	64				
3	Pendulum Aquacap	128	0.05	0.15	0.15	0.01
3rd year	Hyvar XL	64				
	RoundUp Custom ATU	64				
4	Plateau	12	0.05	0	0	0.01
3rd year	Esplanade Sure	5				
	Oust Extra	4				
	Segment II	32				

Table 4. Percent broadleaf weed (BLW) cover for herbicide treatments at 29, 71, 91, & 121 days after treatment (DAT). The site was visually rated on June 17, July 29, August 18, & September 17, 2025. Treatments were applied May 19, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/ac	% BLW Cover 6/17/25 29 DAT	% BLW Cover 7/29/25 71 DAT	% BLW Cover 8/18/25 91 DAT	% BLW Cover 9/17/25 121 DAT
1	Untreated	--	20	35	35	35
2	Prodiamine 65 WDG	32	0.24	0.95	1	2.5
3rd year	Hyvar XL	64				
	RoundUp Custom ATU	64				
3	Pendulum Aquacap	128	0.2	0.35	0.35	0.5
3rd year	Hyvar XL	64				
	RoundUp Custom ATU	64				
4	Plateau	12	0.1	0	0	0.01
3rd year	Esplanade Sure	5				
	Oust Extra	4				
	Segment II	32				

EFFICACY OF FREQUENCY IN BAREGROUND APPLICATIONS

Herbicide trade and common names: Arsenal Powerline *(imazapyr),* Esplanade 200 SC *(indaziflam),* Frequency *(topramezone)*, Hyvar XL *(bromacil),* Method 240SL *(aminocyclopyrachlor),* Oust Extra *(sulfometuron-methyl+metsulfuron-methyl),* Pendulum Aquacap *(pendimethalin),* Plateau *(imazapic)*, RoundUp Custom ATU *(glyphosate)*

Plant common and scientific names: kochia *(Kochia scoparia)*; switchgrass *(Panicum virgatum)*; fine fescue *(Festuca spp.)*; tall fescue *(Schedonorus arundinaceus)*; foxtail *(Setaria spp.)*; birdsfoot trefoil *(Lotus corniculatus)*; common teasel *(Dipsascus fullonum)*

ABSTRACT

Bareground weed control programs rely on herbicide mixes applied annually around guiderails, signposts, and reflective delineators, and other structures. Various herbicide treatments were evaluated in combination with Frequency and compared to the standard bareground mix, and an untreated check for this application. The herbicide treatments included Method 240SL at 12 oz/ac + Esplanade 200 SC at 5 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (this is the standard bareground mix); Frequency at 10 oz/ac + Oust Extra at 4 oz/ac + RoundUp Custom ATU at 64 oz/ac; Frequency at 12 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac; Frequency at 10 oz/ac + Plateau at 8 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac; Frequency at 10 oz/ac + Pendulum Aquacap at 64 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25% v/v. All of the herbicide treatments provided season long bareground weed control comparable to the standard mix.

INTRODUCTION

The bareground weed control program utilizes herbicides to eliminate vegetation and provide season long vegetation control under guiderails, around signposts, and other structures like concrete dividers and traffic islands. The development of herbicide resistant weed populations is a continual concern where repeated use of the same herbicide mix is chosen to maintain these bareground areas. Bareground herbicide mixes used by PennDOT to manage these areas often rely on just a few sites of action. Identifying herbicides with alternative sites of action for use in bareground mixes is important for reducing the potential development of herbicide resistant weeds and sustaining the current effective chemistries used for weed control. One active ingredient that may have efficacy on various weeds including kochia is topramezone. Frequency, containing the active ingredient topramezone, provides both pre-emergence and systemic post emergence control of various grass and broadleaf weed species[25].

[25] BASF Corporation. Frequency label. https://www.cdms.telusagcg.com/ldat/ld95S004.pdf

MATERIALS AND METHODS

The experiment was established behind a guiderail along I-99 northbound (mile marker 56.6-57.4) between Bald Eagle and Port Matilda, PA. The site was chosen due to the presence of kochia (*Kochia scoparia* (L.) Schrad.) observed the prior year along this stretch of guiderail. Treatments included Method 240SL at 12 oz/ac + Esplanade 200 SC at 5 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac; Frequency at 10 oz/ac + Oust Extra at 4 oz/ac + RoundUp Custom ATU at 64 oz/ac; Frequency at 12 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac; Frequency at 10 oz/ac + Plateau at 8 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac; Frequency at 10 oz/ac + Pendulum Aquacap at 64 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25% v/v. The study was established as a randomized complete block design with three replications with plots 20 by 4 feet in size. The applications were pre-measured, mixed, and applied on May 20, 2025 using a CO_2 powered backpack sprayer equipped with an OC-O6 nozzle operating at 32 PSI and delivered 50 gallons per acre. Weather at the time of application was partly cloudy with wind speeds of 0-5 MPH, 57% relative humidity, air temperature of 57°F, and soil temperatures of 62°F, 63°F, 65°F, and 66°F at 0, 1, 3, and 6-inch depths. Local rain events occurred on May 21 and 22 with 0.65", and 0.46" respectively, with the closest weather station located in Rock Springs, PA, according to https://newa.cornell.edu.

The experiment was visually rated for percent total vegetative cover on May 20, June 17, July 14, August 18, and September 17, 2025, 0, 28, 55, 90 and 120 days after treatment (DAT). Additionally, percent grass cover, percent broadleaf weed cover and percent kochia cover were visually rated on June 17, July 14, August 18, and September 17, 2025, 28, 55, 90, and 120 DAT. A killing frost occurred on October 10, 2025 at the site effectively ending the experiment. All data were subjected to analysis of variance and when F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Plots were initially rated on May 20 and ranged from 10 to 13.3 percent total cover with no significance among treatments (Table 1). For all herbicide treatments, from June 17 through September 17, percent total cover was reduced while the untreated plots increased. At the final rating for the experiment (September 17) all herbicide treatments were statistically similar and significantly different from the untreated check. The treatment with the lowest percent total cover was Frequency at 12 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac (6.8%) followed by Frequency at 10 oz/ac + Pendulum Aquacap at 64 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (8.7%); Frequency at 10 oz/ac + Oust Extra at 4 oz/ac + RoundUp Custom ATU at 64 oz/ac (9%); Frequency at 10 oz/ac + Plateau at 8 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (9.1%); Method 240SL at 12 oz/ac + Esplanade 200 SC at 5 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (10.2%) with the untreated check at 43.3%.

Percent grass cover was initially rated on June 17 and ranged from 2.2 to 9.3 (Table 2). All treatments were statistically similar. By the last rating on September 17, percent grass cover

for all treatments was statistically similar with the lowest being Frequency at 10 oz/ac + Oust Extra at 4 oz/ac + RoundUp Custom ATU at 64 oz/ac (1%) followed by Method 240SL at 12 oz/ac + Esplanade 200 SC at 5 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (1.2%); Frequency at 10 oz/ac + Plateau at 8 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (3.1%); Frequency at 10 oz/ac + Pendulum Aquacap at 64 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (3.7%); Frequency at 12 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac (3.8%) and the untreated check (7.3%).

Broadleaf weed cover was rated on June 17 and ranged from 0.1 to 0.3 percent for the herbicide treatments with the untreated check at 15.7 percent (Table 3). By September 17, 120 DAT, the treatment with the lowest broadleaf weed cover was Frequency at 12 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac (3%) followed by Frequency at 10 oz/ac + Pendulum Aquacap at 64 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (5%); Frequency at 10 oz/ac + Plateau at 8 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (6%); Frequency 10 oz/ac + Oust Extra 4 oz/ac + RoundUp Custom ATU 64 oz/ac (8%) and Method 240SL at 12 oz/ac + Esplanade 200 SC at 5 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (9%). Percent broadleaf weed cover was significantly different for all herbicide treatments compared to the untreated check (36%).

Percent kochia cover was rated June 17, July 14, August 18, and September 17 (Table 4). On June 17 28 DAT, the untreated plots had 14.2% kochia cover and ranged from 0.1-0.2 % kochia cover for the herbicide treatments. Percent kochia cover continued to increase for each rating through September 17 120 DAT, the untreated check had 30.7% kochia cover. Frequency at 12 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac resulted in the lowest kochia cover (2.7%) followed by Frequency at 10 oz/ac + Pendulum Aquacap at 64 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (4.8%), Frequency at 10 oz/ac + Plateau at 8 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (5.8%), Frequency 10 oz/ac + Oust Extra 4 oz/ac + RoundUp Custom ATU 64 oz/ac (8%), and Method 240SL at 12 oz/ac + Esplanade 200 SC at 5 oz/ac + Arsenal Powerline at 8 oz/ac + RoundUp Custom ATU at 64 oz/ac (9%).

The common weed species identified in the untreated check plots during the September rating included kochia, switchgrass, and foxtail. In addition, birdsfoot trefoil, common teasel, and wild carrot were found in at least one of the untreated check plots. On the outside edge of the plots tall fescue and fine fescue were noted. It appears that the application did not completely control the fine fescue or tall fescue. Also, some switchgrass was not controlled because it was not actively growing at application. As far as trends observed based on herbicide mix, it appears that the higher rate of Frequency (12 oz/ac) may have slightly reduced kochia and, in turn, total and broadleaf weed cover. When Frequency was paired with Pendulum Aquacap foxtail only appeared in one plot.

CONCLUSIONS

All of the herbicide treatments provided season long bareground weed control comparable to the standard herbicide mix. One treatment, Frequency at 12 oz/ac + Hyvar XL at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac resulted in less than 7 percent total vegetative cover (6.8%) and the least kochia cover (2.7%) at 120 DAT. The remaining herbicide treatments though not statistically different than other treatments had around 10 percent or less total vegetative cover.

MANAGEMENT IMPLICATIONS

Bareground weed control is one of the main programs used by roadside specialists throughout Pennsylvania. In some areas, kochia has continued to be a problematic weed in bareground locations. In areas where kochia may be escaping herbicide treatments, Frequency may be a tank mix partner to consider, especially if scouting shows kochia had germinated prior to application. Frequency in a bareground mix provides post emergence and some pre-emergence residual control. The half-life of Frequency is 14 days, so this product does not provide long residual control. However, Frequency may fit into a bareground program where kochia is problematic and already germinated. When Frequency is used in a bareground mix it may provide post emergence activity, lengthen the application window, and should be used in conjunction with a preemergence herbicide. To date, kochia has not developed resistance to this group of herbicides (Site of Action 27). It appears the higher rate of Frequency may provide better weed control. Unfortunately, the experiment did not include similar herbicide mixes comparing different rates, for example 10 oz/ac of Frequency to higher rates of 12 or 16 oz/ac. Future research should also evaluate the effectiveness of Frequency foliar applications on small to mid-sized kochia.

Table 1. Percent total vegetative cover for herbicide treatments at 0, 28, 55, 90, & 120 days after treatment (DAT). The site was visually rated on May 20, June 17, July 14, August 18, & September 17, 2025. Treatments were applied May 20, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v. Each value is the mean of three replications. Column means followed by the same letter are not significantly different.

Treat-ment	Product	Rate oz/acre	% Total Cover 5/20/25 0 DAT	% Total Cover 6/17/25 28 DAT	% Total Cover 7/14/25 55 DAT	% Total Cover 8/18/25 90 DAT	% Total Cover 9/17/25 120 DAT
1	Untreated	--	13.3	25 b	31.7 b	33.3 b	43.3 b
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	10.7	5.5 ab	2.8 a	4.8 a	10.2 a
3	Frequency Oust Extra RoundUp Custom ATU	10 4 64	10	2.3 a	0.7 a	4 a	9 a
4	Frequency Hyvar XL RoundUp Custom ATU	12 64 64	12.3	2.5 a	2.5 a	3.5 a	6.8 a
5	Frequency Plateau Arsenal Powerline RoundUp Custom ATU	10 8 8 64	11.7	3.6 a	1.1 a	4.5 a	9.1 a
6	Frequency Pendulum Aquacap Arsenal Powerline RoundUp Custom ATU	10 64 8 64	12.7	4 a	2.5 a	3.6 a	8.7 a
			n.s.				

Table 2. Percent grass cover for herbicide treatments at 28, 55, 90, & 120 days after treatment (DAT). The site was visually rated on June 17, July 14, August 18, & September 17, 2025. Treatments were applied May 20, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v. Each value is the mean of three replications. Column means followed by the same letter are not significantly different.

Treat-ment	Product	Rate oz/acre	% Grass Cover 6/17/25 28 DAT	% Grass Cover 7/14/25 55 DAT	% Grass Cover 8/18/25 90 DAT	% Grass Cover 9/17/25 120 DAT
1	Untreated	--	9.3	7.3 b	7.3	7.3
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	5.3	2.3 ab	2.3	1.2
3	Frequency Oust Extra RoundUp Custom ATU	10 4 64	2.2	0.2 a	0.3	1
4	Frequency Hyvar XL RoundUp Custom ATU	12 64 64	2.4	1.9 ab	2.7	3.8
5	Frequency Plateau Arsenal Powerline RoundUp Custom ATU	10 8 8 64	3.4	0.3 a	2.6	3.1
6	Frequency Pendulum Aquacap Arsenal Powerline RoundUp Custom ATU	10 64 8 64	3.7	2 ab	2.2	3.7
			n.s.		n.s.	n.s.

Table 3. Percent broadleaf weed cover (BLW) for herbicide treatments at 28, 55, 90, & 120 days after treatment (DAT). The site was visually rated on June 17, July 14, August 18, & September 17, 2025. Treatments were applied May 20, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v. Each value is the mean of three replications. Column means followed by the same letter are not significantly different.

Treat-ment	Product	Rate oz/acre	% BLW Cover 6/17/25 28 DAT	% BLW Cover 7/14/25 55 DAT	% BLW Cover 8/18/25 90 DAT	% BLW Cover 9/17/25 120 DAT
1	Untreated	--	15.7 b	24.3 b	26 b	36 b
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	0.2 a	0.5 a	2.5 a	9 a
3	Frequency Oust Extra RoundUp Custom ATU	10 4 64	0.1 a	0.5 a	3.7 a	8 a
4	Frequency Hyvar XL RoundUp Custom ATU	12 64 64	0.1 a	0.6 a	0.8 a	3 a
5	Frequency Plateau Arsenal Powerline RoundUp Custom ATU	10 8 8 64	0.2 a	0.8 a	1.9 a	6 a
6	Frequency Pendulum Aquacap Arsenal Powerline RoundUp Custom ATU	10 64 8 64	0.3 a	0.5 a	1.4 a	5 a

Table 4. Percent kochia cover for herbicide treatments at 28, 55, 90, & 120 days after treatment (DAT). The site was visually rated on June 17, July 14, August 18, & September 17, 2025. Treatments were applied May 20, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v. Each value is the mean of three replications. Column means followed by the same letter are not significantly different.

Treat-ment	Product	Rate oz/acre	% Kochia Cover 6/17/25 28 DAT	% Kochia Cover 7/14/25 55 DAT	% Kochia Cover 8/18/25 90 DAT	% Kochia Cover 9/17/25 120 DAT
1	Untreated	--	14.2 b	21.3 b	23.3 b	30.7 b
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	0.1 a	0.5 a	2.5 a	9 ab
3	Frequency Oust Extra RoundUp Custom ATU	10 4 64	0.1 a	0.5 a	3.7 a	8 ab
4	Frequency Hyvar XL RoundUp Custom ATU	12 64 64	0.1 a	0.5 a	0.8 a	2.7 a
5	Frequency Plateau Arsenal Powerline RoundUp Custom ATU	10 8 8 64	0.2 a	0.8 a	1.9 a	5.8 a
6	Frequency Pendulum Aquacap Arsenal Powerline RoundUp Custom ATU	10 64 8 64	0.2 a	0.5 a	1.3 a	4.8 a

COMPATABILIBTY OF GRASS AND BROADLEAF WEED HERBICIDES USED IN BAREGROUND MIXES

Herbicide trade and common names: Arsenal Powerline *(imazapyr)*, Echelon 4 SC *(sulfentrazone+prodiamine),* Fusilade II *(fluaziflop-P-butyl),* Method 240SL *(aminocyclopyrachlor),* Oust Extra *(sulfometuron-methyl+metsulfuron-methyl),* Pendulum Aquacap *(pendimethalin),* Segment II *(sethoxydim),* TerraVue *(aminopyralid + florpyrauxifen-benzyl)*

Plant common and scientific names: lovegrass (*Eragrostis spp*.), dropseed (*Sporobolus spp*.), broomsedge *(Andropogon virginicus)*, purpletop *(Tridens flavus)*, foxtail *(Setaria spp.),*tall fescue *(Schedonorus arundinaceus* (Schreb.) Dumort.*)*, Kentucky bluegrass (*Poa pratensis* L.*)*, smooth bromegrass *(Bromus inermis L.)*, mugwort *(Artemisia vulgaris L.)*, spurge *(Euphorbia spp.)* wild carrot *(Daucus carota* L.*)*, American burnweed *(Erechtites hieraciifolius* (L.) Raf. ex DC.*)*, common mullein *(Verbascum thapsus* L.*)*, white sweet clover *(Melilotus albus)*, common ragweed *(Ambrosia artemisiifolia* L.*)*, aster *(Symphyotrichum spp.),* birdsfoot trefoil *(Louts corniculatus* L.*)*, black medic *(Medicago lupulina* L.*)*, purple loosestrife *(Lythrum salicaria* L.*)*

ABSTRACT

Past experiments have evaluated bareground mixes that did not use *glyphosate* with varied results. The purpose of this experiment was to determine if antagonism occurs in grass and broadleaf weed control when mixing Segment II (*sethoxydim*) with Method 240SL (*aminocyclopyrachlor*) and Fusilade II *(fluaziflop-p)* with TerraVue (*aminopyralid + florpyrauxifen-benzyl*) along with other common bareground herbicides. The experiment was established as a randomized complete block design with three replications under a guiderail along SR 764 near Pinecroft, PA. Treatments included Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac, TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac, Segment II at 32 oz/ac, Fusilade II at 24 oz/ac, TerraVue at 5 oz/ac, Method 240SL at 12 oz/ac, and an untreated check.

By the end of the experiment, no significant differences were noted in percent total cover among the treatments, and all were similar to the untreated check ranging from 26.7 to 60 percent. Both Segment II and Fusilade II showed less but statistically similar grass cover compared to mixes that included these herbicides, that is Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac and TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac. Interestingly, TerraVue alone was statistically similar based on broadleaf weed cover compared to TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac throughout the experiment. Whereas Method 240SL at 12 oz/ac was statistically similar based on broadleaf cover to Method 240SL at 12 oz/ac + Echelon 4SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac through 31 DAT, however, Method 240SL alone had significantly less broadleaf cover compared to the mix at 62 DAT and less but not significant at 94 DAT.

INTRODUCTION

Bareground weed control applications are applied under guiderails and around signposts and other structures to provide season long vegetation control. The development of herbicide resistant weed populations is a continual concern where the same herbicides are used to maintain these bareground areas. Typically, herbicide resistant weed species have an annual life cycle. Bareground mixes are used by PennDOT to manage these areas but rely on just a few sites of action. Herbicide mixes often consist of a non-selective postemergence (*glyphosate*), pre-emergence, and broad-spectrum residual herbicide. Identifying herbicides with alternative site of action for use in bareground mixes is important for reducing herbicide resistance and identifying new effective chemistries for weed control. Finding an herbicide to replace *glyphosate* in bareground mixes has been difficult. Past experiments have evaluated bareground mixes that did not use *glyphosate.* Mixes combining grass and broadleaf herbicides were used to replace *glyphosate*, with varied results[26,27]. Research has shown antagonism occurred resulting in reduced weed control when mixing some grass and broadleaf weed herbicides[28]. The purpose of this experiment is to determine if antagonism occurs in grass and broadleaf weed control when mixing Segment II (*sethoxydim*) with Method 240SL (*aminocyclopyrachlor*) and Fusilade II (*fluaziflop-p*) with TerraVue (*aminopyralid*) along with other common bareground herbicides.

MATERIALS AND METHODS

The experiment was established under a guiderail along SR 764 near Pinecroft, PA. The site was chosen due to the presence of a variety of annual grass and broadleaf weeds observed the prior year. In addition, the site was not sprayed the prior year in 2024. Treatments included Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac, TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac, Segment II at 32 oz/ac, Fusilade II at 24 oz/ac, TerraVue at 5 oz/ac, Method 240SL at 12 oz/ac, and an untreated check. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25% v/v except treatments including Segment II in the mix, which added MSO at 1% v/v per label recommendations. The experiment was arranged as a randomized complete block design with three replications and plots 20 by 4 feet in size. The applications were pre-measured, mixed, and applied on June 13, 2025 using a CO_2-powered backpack sprayer equipped with an OC-O6 nozzle operating at 32 PSI and delivering 50 gallons per acre. Weather at the time of application was partly sunny with wind speeds of 0-5 MPH, 68% relative humidity, air temperature of 69°F, and soil temperatures of 64°F, 64°F, 64°F, and 64°F at 0, 1, 3, and 6-inch depths. Local rain events occurred on June 14, 15, 16, 17 and 18 with amounts 0.55”, 0.01”, 0.31”, 1.71”, and 0.44” respectively, and the closest weather station located in Altoona, PA, according to https://newa.cornell.edu/all-weather-data-query.

[26] Jodon et.al 2023. Evaluation of Bareground Herbicide Mixes without Glyphosate. Roadside Vegetation Management Research-2023 Report pp 53-63.
[27] Jodon et.al 2024. Evaluation of Alternative Bareground Herbicide Mixes. Roadside Vegetation Management Research-2024 Report pp 39-54.
[28] Minton, B.W., Kurtz, M.E. and Shaw, D.R. (1989) ‘Barnyardgrass (Echinochloa crus-galli) Control with Grass and Broadleaf Weed Herbicide Combinations’, *Weed Science*, 37(2), pp. 223–227. doi:10.1017/S0043174500071824.

The experiment was visually rated for percent total vegetative cover, percent grass cover, and percent broadleaf weed cover on June 12, July 1, July 14, August 14, & September 15, 2025, 0, 18, 31, 62, & 94 days after treatment (DAT). A killing frost occurred on October 10, 2025 at the site effectively ending the experiment. All data were subjected to analysis of variance and when F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

The plots were rated prior to treatment on June 12 and ranged from 56.7 to 66.7 percent total cover with no significance among treatments (Table 1). Eighteen days after treatment, percent total cover for all herbicide treatments and the untreated check were reduced. Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac showed 14.7 percent total cover, while TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac showed 4 percent total cover. By 31 DAT, percent total cover remained the same or increased slightly for all herbicide treatments except Fusilade II at 24 oz/ac which decreased. By August 14, 62 DAT, percent total cover increased for all treatments except Segment II at 32 oz/ac which stayed the same. Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac showed 24.3 percent total cover while TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac showed 15 percent total cover. The last rating for the experiment occurred on September 15 with all treatments statistically similar including the untreated check, ranging from 26.7 to 60 percent total cover.

Grass cover was initially rated on June 12, 0 DAT, and ranged from 15.7 to 23.3 (Table 2) with all treatments statistically similar. By July 1, 18 DAT, percent grass cover was reduced for all treatments. Evaluating treatments containing grass herbicides: Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac showed 3.3 percent grass cover reducing initial grass cover by 85% while TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac showed 2.8 percent reducing initial grass cover by 87%, Segment II at 32 oz/ac showed 2.5 percent grass cover, reducing initial grass cover by 85%; and Fusilade II at 24 oz/ac showed 7.7% grass cover, reducing initial grass cover by 67%.

On July 14, 31 DAT, Fusilade II showed less grass cover when compared to 18 DAT (18 DAT 7.7% 30 DAT 4.3%). According to the Herbicide Handbook Tenth Edition, Fusilade II (*fluaziflop-P),* is slow to translocate and may take up to 3 weeks to show signs of necrosis[29]. In addition, the handbook stated that the half-life of *fluaziflop-P* is fifteen days, depending on soils and will provide some soil activity affecting grass seedlings germinating after application. Segment II at 32 oz/ac showed no change in grass cover when compared to 18 DAT, staying at 2.5 percent. According to the Herbicide Handbook, Segment II *(sethoxydim),* is slow to translocate and may take up to 3 weeks to show signs of necrosis[30]. Rounding out notable results 31 DAT, Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac showed 4.7 percent grass cover, while TerraVue at 5 oz/ac + Pendulum

[29] Herbicide Handbook Tenth Edition, 2014. Weed Science Society of America. pp.199-200
[30] Herbicide Handbook Tenth Edition, 2014. Weed Science Society of America. pp.413-414

Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac showed 3.6 percent grass cover. By the final rating, 94 DAT, grass cover for the following treatments was Segment II at 32 oz/ac 5.3%; Fusilade at 24 oz/ac 8.3%; Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac 9.7%; and TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac 24%. Based on percent grass cover results, there appears to be no antagonism between the Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac mixture and Segment II at 32 oz/ac applied alone. In evaluating grass species identified by the last rating, Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac had Eragrostis spp. and/or Sporobolus spp., Kentucky bluegrass, and bromegrass spp. occurred in 2 replications and tall fescue and broomsedge in 1 replication. Grass species identified in Segment II at 32 oz/ac were Eragrostis spp. and/or Sporobolus spp. in all 3 replications, tall fescue in 2 replications, and bromegrass spp. and broomsedge in 1 replication. Likewise, there appears no antagonism when comparing the TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac mixture to Fusilade II at 24 oz/ac. All showed statistically similar percent grass cover. Grass species identified in TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac (24%) plots were Eragrostis spp. and/or Sporobolus spp. occurred in all three replications, broomsedge, purpletop, foxtail spp. occurred in 2 replications and tall fescue in one replication. Grass species identified in Fusilade II at 24 oz/ac were tall fescue in 3 replications, fine fescue in 2 replications, and Kentucky bluegrass and an unknown summer annual grass in 1 replication.

Broadleaf weed cover was rated on June 12, 0 DAT, and ranged from 40 to 47.7 (Table 3) with all treatments statistically similar. By July 1, 18 DAT, percent broadleaf weed cover was reduced for all treatments. Evaluating treatments containing broadleaf weed herbicides: TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac showed 1.2 percent reducing initial broad leaf weed cover by 97%, Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac showed 11.3 percent broad leaf weed cover reducing initial broadleaf weed cover by 74% while TerraVue at 5 oz/ac showed 1.2 percent broadleaf weed cover, reducing initial broadleaf weed cover by 97%; and Method 240SL at 12 oz/ac showed 6 percent broadleaf weed cover, reducing initial broadleaf weed cover by 86%. On July 14, 31 DAT, both TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac and Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac showed slightly less percent broadleaf weed cover, 0.6 and 10.3, respectively. TerraVue at 5 oz/ac and Method 240SL at 12 oz/ac showed slight increases in broadleaf weed cover at 2.3 and 6.3, respectively. By August 14, 62 DAT, TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac and TerraVue at 5 oz/ac were statistically similar with percent broadleaf weed cover at 1.1 and 3, respectively. Method 240SL at 12 oz/ac was statistically similar to the best performing treatments; however, broadleaf cover increased notably for Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac at 6.7 and 20.7 percent, respectively. On September 15, 94 DAT, the best performing treatments for control of broadleaf weeds were TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac and TerraVue at 5 oz/ac both showed 2.7 percent broadleaf weed cover. Method 240SL at 12 oz/ac had 10.7 percent broadleaf weed cover while Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal

Powerline at 8 oz/ac + Segment II at 32 oz/ac had 28.7 percent broadleaf weed cover and were similar to the untreated check.

In comparing treatments to determine if antagonism occurred based on percent broadleaf weed cover Method 240SL at 12 oz/ac applied alone showed statistically significantly less broadleaf weed cover than Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac at 62 DAT indicating reduced control when the herbicides were combined. However, by 94 DAT both treatments were statistically similar but Method 240SL at 12 oz/ac applied alone showed less percent broadleaf weed cover. The common broadleaf weeds identified in the Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac treatment were mugwort (3 replications), spurge spp. (2 replications), wild carrot (2 replications), and American burnweed (2 replications). Common broadleaf weeds identified in Method 240SL at 12 oz/ac were mugwort (3 replications), wild carrot (2 replications), and common mullein (2 replications). In comparing TerraVue at 5oz/ac to the mix TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac to determine antagonism occurred with mixing broadleaf weed herbicides and grass herbicides both treatments showed no antagonism and similar percent broadleaf weed cover throughout the experiment. The common broadleaf weeds identified in the TerraVue at 5 oz/ac treatment were spurge (3 replications) and mugwort (2 replications). The common broadleaf weeds identified in the TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac treatment were spurge (2 replications) and mugwort (2 replications).

The common weed species identified in the untreated check plots during the September rating included American burnweed, sweet clover, ragweed, aster spp., mugwort, wild carrot, Eragrostis/Sporobolus spp., tall fescue, and purpletop, In addition, birdsfoot trefoil, black medic, purple loosestrife, fine fescue spp. and Kentucky bluegrass were found in at least one of the untreated check plots.

CONCLUSIONS

Neither Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac, TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac, Segment II alone or Fusilade II alone killed all grass species present by 18 DAT. By the end of the experiment, both Segment II and Fusilade II showed less but statistically similar grass cover compared to the respective mixes evaluated that included Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac and TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac.

Neither Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac, TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac, Method 240SL alone or TerraVue alone killed all broadleaf weed species present by 18 DAT. TerraVue alone was statistically similar based on broadleaf weed cover compared to TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac throughout the experiment. Interestingly, based on

broadleaf weed cover, Method 240SL was statistically similar to Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac through 31 DAT, however, Method 240SL alone had less broadleaf cover and was significantly different to the mix, Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac at 62 DAT.

In an effort to understand and observe if antagonism occurs when utilizing grass herbicides combined with standard bareground broadleaf herbicide components like Method 240SL or TerraVue, future research should investigate similar mixes comparing different grass herbicides and even different preemergence herbicides. For example, compare TerraVue 5 oz/ac + Esplanade 200SC+ Arsenal Powerline 8 oz/ac + Segment II at 32 oz/ac to TerraVue 5 oz/ac + Esplanade 200SC+ Arsenal Powerline 8 oz/ac + Fusilade II at 24 oz/ac. In addition, compare Method 240 SL in place of TerraVue at 5 oz/ac to the previously listed mixes. Finally, include treatments that compare Echelon 4 SC or Pendulum Aquacap to Esplanade 200SC.

MANAGEMENT IMPLICATIONS

A goal of the project is to develop bareground mixes that can be used to rotate the SOA of all of the herbicide components. It is important to remember that a bareground program should involve using bareground mixes over several years in sequence that rotates the SOA of pre-emergence, broad-spectrum residual, and post emergence herbicides. Identifying bareground mixes that do not use *glyphosate* has been a challenge and past work has shown mixed results. This experiment again showed mixed results. By the end of the experiment, Method 240SL at 12 oz/ac + Echelon 4 SC at 36 oz/ac + Arsenal Powerline at 8 oz/ac + Segment II at 32 oz/ac showed decent grass control but poor broadleaf control, while TerraVue at 5 oz/ac + Pendulum Aquacap at 128 oz/ac + Oust Extra at 4 oz/ac + Fusilade II at 24 oz/ac showed poor grass control but acceptable broadleaf control. Maybe we are seeing some antagonism based on these mixes and adjustments are needed. Will we see different results if we switch Fusilade II with Segment II with the mixes in this experiment? Another variable was not using a consistent preemergence herbicide for this experiment. As stated earlier we should evaluate a bareground mix with a grass herbicide + broadleaf herbicide + broad spectrum residual + Esplanade 200 SC. Some of the weed pressure may have been failure of the preemergence used in the treatments for this experiment. The site received over 3 inches of rain in less than a week after application potentially reducing the effectiveness of Echelon 4SC and Pendulum Aquacap. Also, the grass herbicides used don't have great activity on perennial grass like tall and fine fescue.

Table 1. Percent total vegetative cover at 0, 18, 31, 62, & 94 days after treatment (DAT). The site was visually rated on June 12, July 1, July 14, August 14, & September 15, 2025. Treatments were applied June 13, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v, except treatments including Segment II, which added MSO at 1% v/v. Each value is the mean of three replications. Column means followed by the same letter are not significantly different.

Treatment	Product	Rate oz/ac	%Total Cover 6/12/25 0 DAT	%Total Cover 7/1/25 18 DAT	%Total Cover 7/14/25 31 DAT	%Total Cover 8/14/25 62 DAT	%Total Cover 9/15/25 94 DAT
1	Untreated	--	56.7	45 c	46.7 c	48.3 b	53.3
2	Method 240SL Echelon 4 SC Arsenal Powerline Segment II	12 36 8 32	66.7	14.7 a	15 ab	24.3 a	38.3
3	TerraVue Pendulum Aquacap Oust Extra Fusilade II	5 128 4 24	63.3	4 a	4.2 a	15 a	26.7
4	Segment II	32	60	43.3 c	43.3 c	43.3 b	45
5	Fusilade II	24	63.3	38.3 bc	31.7 bc	42.7 b	41.7
6	TerraVue	5	63.3	16 a	28.3 abc	48.3 b	60
7	Method 240SL	12	61.7	21 ab	31.7 bc	46.7 b	57.3
			n.s.				n.s.

Table 2. Percent grass cover at 0, 18, 31, 62, & 94 days after treatment (DAT). The site was visually rated on June 12, July 1, July 14, August 14, & September 15, 2025. Treatments were applied June 13, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v, except treatments including Segment II, which added MSO at 1% v/v. Each value is the mean of three replications. Column means followed by the same letter are not significantly different.

Treatment	Product	Rate oz/ac	%Grass Cover 6/12/25 0 DAT	%Grass Cover 7/1/25 18 DAT	%Grass Cover 7/14/25 31 DAT	%Grass Cover 8/14/25 62 DAT	%Grass Cover 9/15/25 94 DAT
1	Untreated	--	16.7	11.7 ab	16.7 ab	22 b	26.3 ab
2	Method 240SL Echelon 4 SC Arsenal Powerline Segment II	12 36 8 32	22.3	3.3 a	4.7 a	3.7 a	9.7 a
3	TerraVue Pendulum Aquacap Oust Extra Fusilade II	5 128 4 24	22.3	2.8 a	3.6 a	13.9 ab	24 a
4	Segment II	32	16.7	2.5 a	2.5 a	2.3 a	5.3 a
5	Fusilade II	24	23.3	7.7 ab	4.3 a	4.7 a	8.3 a
6	TerraVue	5	15.7	14.3 b	26 b	45.3 c	57.3 c
7	Method 240SL	12	20	15 b	25.3 b	40 c	46.7 bc
			n.s.				

Table 3. Percent broadleaf weed (BLW) cover at 0, 18, 31, 62, & 94 days after treatment (DAT). The site was visually rated on June 12, July 1, July 14, August 14, & September 15, 2025. Treatments were applied June 13, 2025. A non-ionic surfactant was added to all treatments at 0.25% v/v, except treatments including Segment II, which added MSO at 1% v/v. Each value is the mean of three replications. Column means followed by the same letter are not significantly different.

Treatment	Product	Rate oz/ac	%BLW Cover 6/12/25 0 DAT	%BLW Cover 7/1/25 18 DAT	%BLW Cover 7/14/25 31 DAT	%BLW Cover 8/14/25 62 DAT	%BLW Cover 9/15/25 94 DAT
1	Untreated	--	40	33.3 b	30 b	25.7 b	27 bc
2	Method 240SL Echelon 4 SC Arsenal Powerline Segment II	12 36 8 32	44.3	11.3 a	10.3 a	20.7 b	28.7 bc
3	TerraVue Pendulum Aquacap Oust Extra Fusilade II	5 128 4 24	41	1.2 a	0.6 a	1.1 a	2.7 a
4	Segment II	32	43.3	40.8 b	40.8 b	41 c	39.7 c
5	Fusilade II	24	40	30.7 b	27.3 b	38 c	33.3 c
6	TerraVue	5	47.7	1.2 a	2.3 a	3 a	2.7 a
7	Method 240SL	12	41.7	6 a	6.3 a	6.7 a	10.7 ab
			n.s.				

EVALUATION OF ALTERNATIVE BAREGROUND MIXES AND CONTROL ON KOCHIA *(Kochia scoparia)* ALONG GUIDERAILS

Herbicide trade and common names: Altify IVM *(carfentrazone-ethyl)*, Arsenal Powerline *(imazapyr),* Dicamba 4 *(dicamba)*, Echelon 4 SC *(prodiamine + sulfentrazone)*, Esplanade 200 SC *(indaziflam)*, Method 240SL *(aminocyclopyrachlor)*, Oust Extra *(sulfometuron-methyl + metsulfuron-methyl),* Plainview SC *(indaziflam + aminocyclopyrachlor + imazapyr)*, Portfolio IVM *(sulfentrazone)*, Piper EZ *(flumioxazin + pyroxasulfone)*, Prodiamine WDG *(prodiamine),* Promenade WDG *(flumioxazin)*, RoundUp Custom ATU *(glyphosate),* TerraVue *(aminopyralid + florpyrauxifen-benzyl)*

Plant common and scientific names: kochia *(Kochia scoparia),* birdsfoot trefoil *(Lotus corniculatus),* common teasel *(Dipsascus fullonum),* yellow foxtail *(Setaria glauca)*, switchgrass *(Panicum virgatum)*, Kentucky bluegrass *(Poa pratensis),* fine fescue *(Festuca spp.)*, tall fescue *(Schedonorus arundinaceus)*, slender wheatgrass *(Elymus trachycaulus)*

ABSTRACT

Control of vegetation around guiderails is one of the main tasks of roadside vegetation management. Kochia has become an increasingly widespread problem species in these bareground sites. This experiment looked at a variety of herbicide mixes to determine which achieved the best overall bareground control and more specifically their ability to control kochia. The experiment was established along a guiderail that had a notable population of kochia and a visually similar distribution across the site based on observations made the previous year. The experiment was applied on April 24, 2025. By the last rating on September 26, 2025, total vegetative cover ranged from 0.19 to 9.25 percent. The treatment with the lowest total vegetative cover was Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre with 0.19 percent. Other treatments below 1 percent total vegetative cover were Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.25%) and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.96%). Three treatments showed 0 percent kochia cover by the last rating with Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre, Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre, and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre.

INTRODUCTION

Control of vegetation along guiderails is one of the primary programs of roadside vegetation management providing improved sign visibility, effective water runoff from travel lanes, and safer emergency stops. Bareground mixes are typically applied in the spring or early summer to provide control throughout most of the growing season. A bareground mix typically consists of three components: a post-emergent herbicide killing any established plants on site, a preemergent herbicide controlling any potential plants that have not yet germinated, and a broad spectrum residual herbicide providing some post emergent control while also having lingering

soil residual activity to control emerging weeds. Guiderail areas generally require annual total vegetation control treatments and are the setting for this experiment.

The purpose of this experiment was to evaluate bareground mixes for their effectiveness at total vegetation control and control of kochia. Kochia, an invasive, herbaceous annual, has become a common and difficult plant to control in bareground settings. Kochia's ability to produce tens of thousands of seeds per plant and to grow in harsh soil has allowed it to become a frequent problem species on roadsides. Kochia has also developed resistance to various herbicides in many parts of the country, further increasing control problems. Resistance to herbicides categorized by the WSSA as group 2 (sulfometuron-methyl, metsulfuron-methyl, triasulfuron, and chlorsulfuron), and group 4 (dicamba) have been found in roadside environments.[31] Kochia can range in height from about 12 to 60 in. tall and has a bushy appearance with many branches growing upward. It has small lanceolate leaves with fine hairs[32]. The flowers are small and inconspicuous and develop into many small clusters of brown seeds.

MATERIALS AND METHODS

An experiment was established along a roadside guiderail testing various herbicide mixes for season long total vegetation control. The experiment was located on northbound I-99 between mile markers 56.6-57.4. The site was chosen due to the presence of numerous kochia skeletons from the previous year ensuring the presence of the target species. Induce, a non-ionic surfactant at 0.25% v/v and RoundUp Custom ATU at 64 oz/ac was added to all herbicide treatments. Treatments included Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre; Promenade WDG at 12 oz/acre + Oust Extra at 4 oz/acre; Piper EZ at 20 oz/acre + Oust Extra at 4 oz/acre; TerraVue at 5 oz/acre + Echelon 4 SC at 36 oz/acre + Arsenal Powerline at 8 oz/acre; TerraVue at 5 oz/acre + Prodiamine 65 WDG at 32 oz/acre + Oust Extra at 4 oz/acre; Promenade WDG at 12 oz/acre + Arsenal Powerline at 8 oz/acre; Plainview SC at 48 oz/acre; Plainview SC at 64 oz/acre; Plainview SC at 48 oz/acre + Portfolio IVM at 8 oz/acre; Plainview SC at 48 oz/acre + Altify IVM at 2 oz/acre; Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre; Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Portfolio IVM at 8 oz/acre; Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Altify IVM at 2 oz/acre; Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Dicamba 4 at 32 oz/acre; Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre; Plainview SC at 48 oz/acre + Echelon 4 SC at 24 oz/acre; Plainview SC at 48 oz/acre + Echelon 4 SC at 36 oz/acre; and Piper EZ at 20 oz/acre + Arsenal Powerline at 8 oz/acre. Plots were 20 by 4 feet in size. The applications were pre-measured, mixed, and applied on April 24, 2025, using a CO_2 powered backpack sprayer equipped with an OC-O6 nozzle operating at 31 PSI and delivering 50 gallons per acre. Weather at the time of application was sunny with wind speeds of 5-10 MPH, 31 percent relative humidity, air temperature of 74°F, and soil temperatures of 82F, 82F, 74F, and 65F at 0-, 1-, 3-, and 6-inch depths. Local rain events occurred on April 25, 26, and 29, and May 1 and 2 with 0.1", 0.4", 0.12", 0.62", and 0.46" respectively, according to https://newa.cornell.edu. The experiment was visually rated for percent total vegetative cover, percent grass cover, and percent broadleaf weed (BLW) cover on April 16, May 27, June 23, July

[31] International Herbicide-Resistant Weed Database. https://www.weedscience.org/Pages/Herbicide.aspx
[32] Neal, JC.; Uva, RH; DiTomaso, JM; & DiTommaso, A 2023. Weeds of the Northeast Second Edition. Ithaca: Cornell University Press

23, August 21, and September 26, 2025. Percent kochia cover was visually rated on May 27, June 23, July 23, August 21, and September 26, 2025. A frost occurred on October 10, 2025, which ended the growing season. All data were subjected to analysis of variance and when treatment F-tests were significant ($p \leq 0.05$), treatments means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Plots were rated prior to application on April 16, 2025, and ranged from 10.5 to 20.88 percent total vegetative cover with no statistical difference between treatments (Table 1). By May 27 total vegetative control ranged from 0.38 percent (Piper EZ at 20 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre) to 4.13 percent (Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Portfolio IVM at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre) while the untreated was 30 percent 33 days after treatment (DAT). On June 23 total vegetative cover ranged from 0.03 percent (Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre) to 2.18 percent (Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + RoundUp Custom ATU at 64 oz/acre) while the untreated was 32.5 percent 60 DAT. On July 23, total vegetative cover ranges from 0.03 percent (Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre, Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre) to 11.5 percent (TerraVue at 5 oz/acre + Prodiamine 65 WDG at 32 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre) while the untreated was 52.5 percent 90 DAT. On August 21, total vegetative cover ranges from 0.2 percent (Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre) to 19.63 percent (TerraVue at 5 oz/acre + Prodiamine 65 WDG at 32 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre) while the untreated was 62.5 percent 119 DAT. By September 26, total vegetative control ranges from 0.19 percent (Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre) to 19 percent (TerraVue at 5 oz/acre + Prodiamine 65 WDG at 32 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre) while the untreated was 53.75 percent 155 DAT.

The general trend for all herbicide treatments was a decrease in percent total vegetative cover from Apil to May. Starting from the May rating through the last rating in September, all herbicide treatments were significantly different from the untreated check. In July certain treatments started to differ in significance from one another and fell into two categories with the first set having the lowest total vegetative cover (marked as "a") and the second having significantly more total vegetative cover (marked as "b"). Some treatments were statistically similar to both group a and b and were marked by both letters (marked as "ab"). Beginning with the July rating the untreated check fell into a third group c as it had significantly more total vegetative cover.

At the final rating on September 26 (155 DAT) the treatment with the lowest total vegetative cover was Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre with 0.19 percent. Other treatments below 1 percent total cover were Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.25%) and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.96%). Treatments under 2 percent total vegetative cover were

Plainview SC at 48 oz/acre + Portfolio IVM at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.81%) and Piper EZ at 20 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.86%). All remaining treatments had greater than 2 percent total vegetative cover.

Total grass cover for herbicide treatments ranged from 0.06 to 8.25 percent while the untreated check was 15.5 percent on September 26, 2025 (155 DAT) (Table 2). Herbicide treatments that resulted in less than 1 percent total grass cover were Promenade WDG at 12 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.06%), Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.19%), Plainview SC at 48 oz/acre + Echelon 4 SC at 36 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.21%), Plainview SC at 48 oz/acre + Echelon 4 SC at 24 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.25%), Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.25%), Plainview SC at 48 oz/acre + Portfolio IVM at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.25%), Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.34%), and Plainview SC at 48 oz/acre + Altify IVM at 2 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.88%). Treatments with total grass cover between 1 and 2 percent were Piper EZ at 20 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre (1%), Plainview SC at 48 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.08%), and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Altify IVM at 2 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.4%). All other treatments exceeded 2 percent total grass cover.

Total broadleaf weed cover for herbicide treatments ranged from 0 to 15.5 percent while the untreated check was 38.25 percent on September 26, 2025 (155 DAT) (Table 3). Treatments below 1 percent broadleaf weed cover on September 26, 2025 were Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre (0%), Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre (0%), Plainview SC at 48 oz/acre + Echelon 4 SC at 36 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.44%), Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.63%), Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.75%), Piper EZ at 20 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.86%). Treatments between 1 and 2 percent broadleaf weed cover were Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Portfolio IVM at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (1%), Piper EZ at 20 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (1%), Plainview SC at 48 oz/acre + Altify IVM at 2 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.44%), Promenade WDG at 12 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.5%), TerraVue at 5 oz/acre + Echelon 4 SC at 36 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.56%), and Plainview SC at 48 oz/acre + Portfolio IVM at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (1.56%).

By September 26, the last rating, all herbicide treatments were statistically similar based on percent kochia cover within the plots (Table 4). Three treatments showed complete control of kochia throughout the experiment including: Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre, Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre, and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre +

Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre with 0 percent kochia cover. Treatments with less than 1 percent kochia cover were Plainview SC at 48 oz/acre + Echelon 4 SC at 36 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.44%), Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.63%), Piper EZ at 20 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.86%), Piper EZ at 20 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.88%), and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Portfolio IVM at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.88%) . The herbicide treatment with the highest percentage of kochia present by September 26, 2025, was TerraVue at 5 oz/acre + Prodiamine 65 WDG at 32 oz/acre + Oust Extra at 4 oz/acre + RoundUp Custom ATU at 64 oz/acre at 15.5 percent while the untreated check was 30 percent. Three herbicide treatments resulted in no kochia cover by the end of the experiment including: Plainview SC at 64 oz/ac + RoundUp Custom ATU at 64 oz/ac, Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre, and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre. When comparing two Dicamba containing treatments to their treatment counterparts that lacked Dicamba the percent kochia cover was above zero with Plainview SC at 48 oz/ac + RoundUp Custom ATU at 64 oz/ac at 2.19 percent and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + RoundUp Custom ATU at 64 oz/acre at 2.75 percent. The presence of dicamba appears to help in kochia control for these herbicide treatments. This may be because dicamba provides some soil residual activity though it has a limited half-life of 14 days.[33] Dicamba may have provided control of kochia seeds that germinated after application due to its soil activity.

A complete list of weed species was taken August 21 and September 26, 2025. Kochia was the most common weed species throughout the site and appeared in 54 of the 76 plots. In the untreated check plots common weeds were teasel (4 of 4), yellow foxtail (4 of 4), birdsfoot trefoil (3 of 4), and slender wheat grass (3 of 4). Other common weed species across all experimental plots included switchgrass (36%), yellow foxtail (33%), and tall fescue (18%). Interestingly, all of the weed species common to the untreated check plots were less common within the herbicide treated plots except for yellow foxtail (33%).

CONCLUSION

No bareground treatments achieved zero vegetative cover by the end of the experiment. At the final rating the mix with the lowest total vegetative cover was Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.19%). Other treatments with total vegetative cover below 1 percent were Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.25%) and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre (0.96%).

Three mixes provided 0 percent kochia cover including: Plainview SC at 64 oz/acre + RoundUp Custom ATU at 64 oz/acre, Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre, and Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre. Plainview SC at 64

[33] Weed Science Society of America. (2007). *Herbicide Handbook* (10th ed.). Weed Science Society of America, p. 139.

oz/acre + RoundUp Custom ATU at 64 oz/acre and Plainview SC at 48 oz/acre + Dicamba 4 at 32 oz/acre + RoundUp Custom ATU at 64 oz/acre both had 0 percent kochia cover and less than 1 percent total vegetative cover at the final rating showing promise both as bareground mixes and offering excellent kochia control. Something to note was that the two herbicide mixes with Dicamba 4 present achieved complete control of kochia. While this is not enough data to definitively determine if dicamba is more effective at controlling kochia future research should expand on this to determine whether this is the case.

MANAGEMENT IMPLICATIONS

A key purpose of this experiment was to determine which bareground mixes could effectively control kochia, an increasingly problematic species along roadsides in Pennsylvania. The experiment demonstrated the possibility that dicamba could be an effective addition to bareground mixes when trying to control kochia. A possible reason for dicamba's effectiveness is its soil activity, which may last up to 14 days, providing additional control of emerging seedlings.[34]

Future work should be done to determine if the addition of dicamba in bareground mixes improves kochia control and if combinations with other preemergent herbicides are effective at controlling kochia. Also, other factors such as the time of application could be adjusted. Herbicide applications earlier in the growing season may allow for greater preemergence control of germinating kochia seeds.

Some of the herbicides used in this experiment have a risk of offsite movement or can cause unintended damage to non-target plant root systems (e.g., Method 240SL[35], Plainview SC[36], TerraVue[37], and Arsenal Powerline[38] labels). Also, the sulfometuron-methyl in Oust Extra can move offsite which occurred in this experiment as there was visual damage caused to plants outside of the experimental plots that contained Oust Extra in their mixes. This was likely caused by significant rainfall that happened after application. It is important to always evaluate a site for soil texture, slope, and drainage patterns that can exacerbate offsite movement by wind or water movement[39]. The use of Plainview at 48 oz/ac and especially 64 oz/ac should be done cautiously as these rates will deliver a higher amount of imazapyr than using the standard rates of Arsenal Powerline commonly used in PennDOT bareground mixes, such as Method 240SL at 12 oz/acre + Esplanade 200 SC at 5 oz/acre + Arsenal Powerline at 8 oz/acre + RoundUp Custom ATU at 64 oz/acre. Arsenal Powerline at 8 oz/ac contains 2 oz/ac of imazapyr while Plainview at 48 and 64 oz/ac contains around 9 and 12 oz/ac of imazapyr, respectively. The amount of imazapyr in Plainview SC at these rates could cause damage to nearby trees along roadsides so it should be used in areas where trees are not present near bareground sites.

---

[34] Bayer CropScience Canada. Dicamba Basics. https://www.cropscience.bayer.ca/articles/traits/dicamba-basics
[35] Bayer CropScience LP. Method 240SL label. http://www.cdms.net/ldat/ldCFU019.pdf
[36] Envu. Plainview SC label. https://bynder.envu.com/m/214f267ca90a80e5/original/Digital_VM_Plainview_label_NA_US_EN.pdf
[37] Corteva Agriscience. Dow Agrosciences LLC TerraVue label. http://www.cdms.net/ldat/ld2IB008.pdf
[38] BASF Corporation. Arsenal Powerline label. http://www.cdms.net/ldat/ld86K002.pdf
[39] Bayer CropScience LP. Oust Extra label. https://www.cdms.net/ldat/ldCJ3001.pdf

Table 1. Percent total vegetative cover for herbicide treatments. The site was visually rated on April 16, May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% Total Cover 4/16/25 0 DAT	% Total Cover 5/27/25 33 DAT	% Total Cover 6/23/25 60 DAT	% Total Cover 7/23/25 90 DAT	% Total Cover 8/21/25 119 DAT	% Total Cover 9/26/25 155 DAT
1	Untreated	---	15.13	30b	32.5b	52.5c	62.50c	53.75c
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	16	1.18a	0.65a	0.38a	0.88a	0.96a
3	Promenade WDG Oust Extra RoundUp Custom ATU	12 4 64	12.81	0.75a	0.15a	1.51a	1.95a	2.31a
4	Piper EZ Oust Extra RoundUp Custom ATU	20 4 64	11.25	0.59a	0.3a	0.14a	1.33a	1.86a
5	TerraVue Echelon 4 SC Arsenal Powerline RoundUp Custom ATU	5 36 8 64	15	1.28a	0.46a	1.65a	5.13a	5.31ab
6	TerraVue Prodiamine 65 WDG Oust Extra RoundUp Custom ATU	5 32 4 64	10.5	1.69a	1.75a	11.5b	19.63b	19b
7	Promenade WDG Arsenal Powerline RoundUp Custom ATU	12 8 64	12.38	1.38a	1.53a	3.78ab	8.13ab	8.03ab
8	Plainview SC RoundUp Custom ATU	48 64	11.75	1.34a	0.53a	1.7ab	2.09a	3.26a
9	Plainview SC RoundUp Custom ATU	64 64	12.88	1a	0.19a	0.03a	0.2a	0.19a
			n.s					

Table 1 (continued). Percent total vegetative cover for herbicide treatments. The site was visually rated on April 16, May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% Total Cover 4/16/25 0 DAT	% Total Cover 5/27/25 33 DAT	% Total Cover 6/23/25 60 DAT	% Total Cover 7/23/25 90 DAT	% Total Cover 8/21/25 119 DAT	% Total Cover 9/26/25 155 DAT
10	Plainview SC Portfolio IVM RoundUp Custom ATU	48 8 64	15.81	1.09a	0.25a	0.45a	0.75a	1.81a
11	Plainview SC Altify IVM RoundUp Custom ATU	48 2 64	15.88	2.36a	0.45a	0.9a	2.56a	2.31a
12	Plainview SC Dicamba 4 RoundUp Custom ATU	48 32 64	10.75	0.44a	0.03a	0.03a	0.19a	0.25a
13	Method 240SL Esplanade 200 SC Portfolio IVM RoundUp Custom ATU	12 5 8 64	20.88	4.13a	1.8a	5.4ab	6.71a	9.25ab
14	Method 240SL Esplanade 200 SC Altify IVM RoundUp Custom ATU	12 5 2 64	20.38	0.9a	0.88a	2.13ab	5.2a	5.78ab
15	Method 240SL Esplanade 200 SC Dicamba 4 RoundUp Custom ATU	12 5 32 64	12.25	1.25a	1.25 a	3.09ab	3.15a	3.31a
16	Method 240SL Esplanade 200 SC RoundUp Custom ATU	12 5 64	15.31	2.31a	2.18a	3.49ab	5.63a	6.63ab
17	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 24 64	13.81	0.75a	0.51a	0.66a	1.21a	6.63ab
18	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 36 64	12.75	0.88a	0.31a	0.81a	1a	2.44a
19	Piper EZ Arsenal Powerline RoundUp Custom ATU	20 8 64	12.13	0.38a	0.5a	1.15a	5.13a	5.63ab
			n.s					

Table 2. Percent grass cover for herbicide treatments. The site was visually rated on April 16, May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% Grass Cover 4/16/25 0 DAT	% Grass Cover 5/27/25 33 DAT	% Grass Cover 6/23/25 60 DAT	% Grass Cover 7/23/25 90 DAT	% Grass Cover 8/21/25 119 DAT	% Grass Cover 9/26/25 155 DAT
1	Untreated	---	9.63	9.63b	10.25b	14.5b	16.25b	15.5b
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	8.75	1a	0.28a	0.11a	0.19a	0.34a
3	Promenade WDG Oust Extra RoundUp Custom ATU	12 4 64	5.31	0.75a	0.06a	0a	0a	0.06a
4	Piper EZ Oust Extra RoundUp Custom ATU	20 4 64	6.31	0.5a	0.15a	0.08a	0.88a	1a
5	TerraVue Echelon 4 SC Arsenal Powerline RoundUp Custom ATU	5 36 8 64	7.75	1.25a	0.38a	1.28a	3.38a	3.75a
6	TerraVue Prodiamine 65 WDG Oust Extra RoundUp Custom ATU	5 32 4 64	7	1.38a	1a	2.5b	2.88a	3.5a
7	Promenade WDG Arsenal Powerline RoundUp Custom ATU	12 8 64	5.88	1.25a	1.15a	1.75a	7.25ab	6.53ab
8	Plainview SC RoundUp Custom ATU	48 64	7.25	1.31a	0.46a	1.25a	1.25a	1.08a
9	Plainview SC RoundUp Custom ATU	64 64	5.88	1a	0.19 a	0.03a	0.2a	0.19a
			n.s					

Table 2 (continued). Percent grass cover for herbicide treatments. The site was visually rated on April 16, May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% Grass Cover 4/16/25 0 DAT	% Grass Cover 5/27/25 33 DAT	% Grass Cover 6/23/25 60 DAT	% Grass Cover 7/23/25 90 DAT	% Grass Cover 8/21/25 119 DAT	% Grass Cover 9/26/25 155 DAT
10	Plainview SC Portfolio IVM RoundUp Custom ATU	48 8 64	8.81	1a	0.13a	0.05a	0.13a	0.25a
11	Plainview SC Altify IVM RoundUp Custom ATU	48 2 64	11.38	2.31ab	0.34a	0.34a	0.69a	0.88a
12	Plainview SC Dicamba 4 RoundUp Custom ATU	48 32 64	4	0.44a	0.03a	0.03a	0.19a	0.25a
13	Method 240SL Esplanade 200 SC Portfolio IVM RoundUp Custom ATU	12 5 8 64	15.75	4ab	1.63a	5.13a	5.88a	8.25ab
14	Method 240SL Esplanade 200 SC Altify IVM RoundUp Custom ATU	12 5 2 64	15.38	0.78a	0.44a	0.63a	1.2a	1.4a
15	Method 240SL Esplanade 200 SC Dicamba 4 RoundUp Custom ATU	12 5 32 64	7.5	1.25a	1.25 a	3.03a	2.9a	2.56a
16	Method 240SL Esplanade 200 SC RoundUp Custom ATU	12 5 64	12.38	2.13ab	1.88a	2.84a	3.31a	3.88a
17	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 24 64	8.31	0.63a	0.34a	0.19a	0.09a	0.25a
18	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 36 64	7	0.81a	0.19a	0.26a	0.25a	0.21a
19	Piper EZ Arsenal Powerline RoundUp Custom ATU	20 8 64	6.38	0.31a	0.31a	0.78a	4.38a	4.63a
			n.s					

Table 3. Percent broadleaf weed (BLW) cover for herbicide treatments. The site was visually rated on April 16, May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% BLW Cover 4/16/25 0 DAT	% BLW Cover 5/27/25 33 DAT	% BLW Cover 6/23/25 60 DAT	% BLW Cover 7/23/25 90 DAT	% BLW Cover 8/21/25 119 DAT	% BLW Cover 9/26/25 155 DAT
1	Untreated	---	5.5	20.38b	22.25b	38c	46.25c	38.25c
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	7.25	0.18a	0.38a	0.26a	0.69a	0.63a
3	Promenade WDG Oust Extra RoundUp Custom ATU	12 4 64	7.5	0a	0.09a	1.51a	1.95a	2.25a
4	Piper EZ Oust Extra RoundUp Custom ATU	20 4 64	4.94	0.09a	0.15a	0.06a	0.45a	0.86a
5	TerraVue Echelon 4 SC Arsenal Powerline RoundUp Custom ATU	5 36 8 64	7.25	0.03a	0.09a	0.38a	1.75a	1.56a
6	TerraVue Prodiamine 65 WDG Oust Extra RoundUp Custom ATU	5 32 4 64	3.5	0.31a	0.75a	9b	16.75c	15.5b
7	Promenade WDG Arsenal Powerline RoundUp Custom ATU	12 8 64	6.5	0.13a	0.38a	2.03a	0.88a	1.5a
8	Plainview SC RoundUp Custom ATU	48 64	4.5	0.03a	0.06a	0.45a	0.84a	2.19a
9	Plainview SC RoundUp Custom ATU	64 64	7	0a	0a	0a	0a	0a
			n.s					

Table 3 (continued). Percent broadleaf weed (BLW) cover for herbicide treatments. The site was visually rated on April 16, May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% BLW Cover 4/16/25 0 DAT	% BLW Cover 5/27/25 33 DAT	% BLW Cover 6/23/25 60 DAT	% BLW Cover 7/23/25 90 DAT	% BLW Cover 8/21/25 119 DAT	% BLW Cover 9/26/25 155 DAT
10	Plainview SC Portfolio IVM RoundUp Custom ATU	48 8 64	7	0.09a	0.13a	0.4a	0.63a	1.56a
11	Plainview SC Altify IVM RoundUp Custom ATU	48 2 64	4.5	0.05 a	0.11a	0.56a	2a	1.44a
12	Plainview SC Dicamba 4 RoundUp Custom ATU	48 32 64	6.75	0 a	0 a	0 a	0 a	0a
13	Method 240SL Esplanade 200 SC Portfolio IVM RoundUp Custom ATU	12 5 8 64	5.13	0.13 a	0.18a	0.28a	0.84a	1a
14	Method 240SL Esplanade 200 SC Altify IVM RoundUp Custom ATU	12 5 2 64	5	0.13 a	0.44a	1.5a	4a	4.38a
15	Method 240SL Esplanade 200 SC Dicamba 4 RoundUp Custom ATU	12 5 32 64	4.75	0 a	0a	0.06a	0.25a	0.75a
16	Method 240SL Esplanade 200 SC RoundUp Custom ATU	12 5 64	2.94	0.19 a	0.30a	0.65a	2.31a	2.75a
17	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 24 64	5.5	0.13 a	0.18a	0.48a	1.13a	2.19a
18	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 36 64	5.75	0.06a	0.13a	0.55a	0.75a	0.44a
19	Piper EZ Arsenal Powerline RoundUp Custom ATU	20 8 64	5.75	0.06a	0.19a	0.38a	0.75a	1a
			n.s					

Table 4. Percent kochia cover for herbicide treatments. The site was visually rated on May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% Kochia Cover 5/27/25 33 DAT	% Kochia Cover 6/23/25 60 DAT	% Kochia Cover 7/23/25 90 DAT	% Kochia Cover 8/21/25 119 DAT	% Kochia Cover 9/26/25 155 DAT
1	Untreated	---	19.56b	21b	32.25b	40.75b	30b
2	Method 240SL Esplanade 200 SC Arsenal Powerline RoundUp Custom ATU	12 5 8 64	0.09a	0.13a	0.26a	0.69a	0.63a
3	Promenade WDG Oust Extra RoundUp Custom ATU	12 4 64	0a	0.09a	1.51a	1.95a	2.25a
4	Piper EZ Oust Extra RoundUp Custom ATU	20 4 64	0.06a	0.15a	0.06a	0.45a	0.86a
5	TerraVue Echelon 4 SC Arsenal Powerline RoundUp Custom ATU	5 36 8 64	0.03a	0.09a	0.38a	1.75a	1.56a
6	TerraVue Prodiamine 65 WDG Oust Extra RoundUp Custom ATU	5 32 4 64	0.31a	0.75a	9b	16.75b	15.5b
7	Promenade WDG Arsenal Powerline RoundUp Custom ATU	12 8 64	0.06a	0.25a	0.65a	0.75a	1.38a
8	Plainview SC RoundUp Custom ATU	48 64	0.03a	0.06a	0.45a	0.84a	2.19a
9	Plainview SC RoundUp Custom ATU	64 64	0a	0a	0a	0a	0a

Table 4 (continued). Percent kochia cover for herbicide treatments. The site was visually rated on May 27, June 23, July 23, August 21, and September 26, 2025. Treatments were applied on April 24, 2025. Induce, a non-ionic surfactant was added to all herbicide treatments at 0.25 percent v/v. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \geq 0.05$.

Treatment	Product	Rate oz/acre	% Kochia Cover 5/27/25 33 DAT	% Kochia Cover 6/23/25 60 DAT	% Kochia Cover 7/23/25 90 DAT	% Kochia Cover 8/21/25 119 DAT	% Kochia Cover 9/26/25 155 DAT
10	Plainview SC Portfolio IVM RoundUp Custom ATU	48 8 64	0.09a	0.13a	0.4a	0.63a	1.56a
11	Plainview SC Altify IVM RoundUp Custom ATU	48 2 64	0.05a	0.11a	0.5a	1.88a	1.25a
12	Plainview SC Dicamba 4 RoundUp Custom ATU	48 32 64	0a	0a	0a	0a	0a
13	Method 240SL Esplanade 200 SC Portfolio IVM RoundUp Custom ATU	12 5 8 64	0a	0.05a	0.15a	0.59a	0.88a
14	Method 240SL Esplanade 200 SC Altify IVM RoundUp Custom ATU	12 5 2 64	0.13a	0.31a	0.75a	1.25a	1.88a
15	Method 240SL Esplanade 200 SC Dicamba 4 RoundUp Custom ATU	12 5 32 64	0a	0a	0a	0a	0a
16	Method 240SL Esplanade 200 SC RoundUp Custom ATU	12 5 64	0.19a	0.3a	0.65a	2.31a	2.75a
17	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 24 64	0.13a	0.18a	0.48a	1.13a	2.19a
18	Plainview SC Echelon 4 SC RoundUp Custom ATU	48 36 64	0.06a	0.13a	0.55a	0.75a	0.44a
19	Piper EZ Arsenal Powerline RoundUp Custom ATU	20 8 64	0.06a	0.19a	0.31a	0.75a	0.88a

APPENDIX

Appendix Table 1. Canopy area and calculated dosage for each plant. The experiment evaluated 9 treatments. Each plant is an individual replication with 10 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
1	2	23	72	95.34	290
2	6	16	48	44.68	136
3	9	10.5	42	24.05	73
4	1	6.5	40	13.19	40
5	3	10	42	22.69	69
6	4	18	50	53.41	162
7	7	9	49	22.78	69
8	8	20	64	73.30	223
9	5	15	56	46.47	141
10	8	12	40	27.23	83
11	1	21.5	62	78.33	238
12	3	14.5	55	43.97	134
13	9	5	26	6.76	21
14	4	5.5	25	7.32	22
15	7	22	70	88.31	269
16	6	21	50	65.06	198
17	2	15	46	39.92	121
18	5	7	31	11.61	35
19	7	14	50	39.10	119
20	9	5	22	5.89	18
21	3	10	25	15.27	46
22	6	14.5	51	41.44	126
23	4	13.5	48	36.23	110
24	2	7.5	42	16.20	49
25	1	14.5	45	37.64	114
26	8	7	35	12.83	39
27	5	15	40	36.00	109
28	3	11.5	40	25.84	79
29	8	12	37	25.66	78
30	9	7.5	29	11.94	36
31	6	16.5	42	42.12	128
32	7	12	42	28.27	86
33	5	15.5	47	42.27	129
34	1	19	55	61.35	187
35	4	15	52	43.85	133

Appendix Table 1 (continued). Canopy area and calculated dosage for each plant. The experiment evaluated 9 treatments. Each plant is an individual replication with 10 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
36	2	12	40	27.23	83
37	6	11.5	28	19.82	60
38	8	11.5	45	28.35	86
39	5	17	52	51.18	156
40	7	13	46	33.47	102
41	3	15	46	39.92	121
42	1	17	63	59.34	180
43	2	15.5	57	49.03	149
44	9	9	35	17.28	53
45	4	15	40	36.00	109
46	8	10	33	18.76	57
47	3	11	48	28.32	86
48	7	18	55	57.33	174
49	1	15	37	34.03	104
50	9	6	29	9.16	28
51	4	7	23	9.16	28
52	6	9.5	43	21.76	66
53	2	10	35	19.63	60
54	5	8	25	11.52	35
55	4	5	20	5.45	17
56	5	4.5	21	5.01	15
57	2	21.5	56	72.70	221
58	9	20	34	47.12	143
59	7	10	27	16.14	49
60	8	12.5	19	17.18	52
61	3	12	25	19.37	59
62	6	5	13	3.93	12
63	1	5	17	4.80	15
64	2	9	24	12.96	39
65	6	12.5	48	33.00	100
66	1	15.5	38	36.18	110
67	3	5	19	5.24	16
68	5	5.5	18	5.64	17
69	7	11.5	18	14.80	45

Appendix Table 1 (continued). Canopy area & calculated dosage for each plant. The experiment evaluated 9 treatments, including an untreated check. Each plant is an individual replication with 10 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
70	4	13	58	40.27	122
71	8	13	42	31.20	95
72	9	8.5	39	17.62	54
73	1	14	43	34.82	106
74	7	14	54	41.54	126
75	4	15	50	42.54	129
76	3	16	48	44.68	136
77	2	7.5	28	11.62	35
78	9	9	23	12.57	38
79	5	13.5	50	37.40	114
80	6	13.5	43	33.28	101
81	8	16.5	48	46.44	141
82	4	7	30	11.30	34
83	7	7	27	10.38	32
84	5	12	48	31.42	96
85	9	12	53	34.03	104
86	3	14	55	42.15	128
87	1	6	22	7.33	22
88	2	13	32	25.53	78
89	8	6.5	20	7.52	23
90	6	14	62	46.43	141

Appendix Table 2. Canopy area of each plant calculated as the surface area of a cylinder. The experiment evaluated 6 treatments. Each plant is an individual replication with 9 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
1	5	9	36	17.67	54
2	3	6	24	7.85	24
3	7	11	53	30.72	93
4	4	18	66	65.97	201
5	6	13	40	30.06	91
6	1	8	39	16.41	50
7	2	11	46	27.36	83
8	3	16	54	48.87	149
9	4	16	62	54.45	166
10	7	7	35	12.83	39
11	2	25	68	101.45	309
12	6	9	41	19.63	60
13	5	7	30	11.3	34
14	1	11	41	24.96	76
15	1	19	62	67.15	204
16	5	7	30	11.3	34
17	4	12	38	26.18	80
18	7	24	65	93.2	283
19	6	33	66	142.55	434
20	2	7	33	12.22	37
21	3	11	28	18.72	57
22	6	10	48	25.31	77
23	1	8	33	14.31	44
24	4	10	38	20.94	64
25	5	14	48	37.87	115
26	7	24	60	87.96	268
27	3	12	35	24.61	75
28	2	12	30	21.99	67
29	2	14	60	45.2	137
30	4	12	44	29.32	89
31	3	9	36	17.67	54
32	5	7	27	10.38	32
33	7	11	38	23.52	72
34	6	12	40	27.23	83
35	1	7	24	9.47	29

Appendix Table 2 (continued). Canopy area of each plant calculated as the surface area of a cylinder. The experiment evaluated 6 treatments. Each plant is an individual replication with 9 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
36	5	10	42	22.69	69
37	2	10	38	20.94	64
38	1	24	50	77.49	236
39	6	16	45	42.59	130
40	4	14	45	36.04	110
41	3	21	62	76.05	231
42	7	24	71	99.48	303
43	7	15	42	37.31	113
44	2	18	59	60.48	184
45	4	15	44	38.62	117
46	6	20	56	66.32	202
47	3	16	48	44.68	136
48	1	9	23	12.57	38
49	5	28	64	112.4	342
50	6	24	60	87.96	268
51	5	15	51	43.2	131
52	3	13	37	28.36	86
53	7	22	58	76.79	234
54	1	10	28	16.58	50
55	4	36	80	182.21	554
56	2	19	52	58.86	179
57	7	8	28	12.57	38
58	5	23	60	83.3	253
59	2	19	54	60.52	184
60	1	18	42	47.12	143
61	3	6	21	7.07	21
62	6	32	70	142.42	433
63	4	12	42	28.27	86

Appendix Table 3. Canopy area of each plant calculated and used to determine dosage. The experiment evaluated 4 treatments. Each plant is an individual replication with 7 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
1	4	19	32	42.28	129
2	3	15	53	44.51	135
3	2	18	57	58.90	179
4	1	15	52	43.85	133
5	1	24	88	117.29	357
6	3	18	50	53.41	162
7	2	11	36	22.56	69
8	4	11	42	25.44	77
9	2	6.5	37	12.34	38
10	4	15	60	49.09	149
11	3	17	44	45.25	138
12	1	12	43	28.80	88
13	4	9	36	17.67	54
14	3	17	42	43.76	133
15	1	16	58	51.66	157
16	2	20	59	68.94	210
17	1	16	55	49.57	151
18	4	16	50	46.08	140
19	3	10	36	20.07	61
20	2	10	22	13.96	42
21	2	20	54	64.58	196
22	3	12	43	28.80	88
23	4	17	48	48.21	147
24	1	19	56	62.18	189
25	4	8	38	16.06	49
26	1	18	60	61.26	186
27	2	15	60	49.09	149
28	3	13	45	32.90	100

Appendix Table 4. Canopy area and calculated dosage for each plant. The experiment evaluated 10 treatments. Each plant is an individual replication with 4 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
1	10	18	51	54.19	165
2	5	17	68	63.05	192
3	4	18	65	65.19	198
4	8	16	57	50.96	155
5	6	11	48	28.32	86
6	3	10	46	24.43	74
7	2	16	48	44.68	136
8	7	18	72	70.69	215
9	9	11	45	26.88	82
10	1	12	44	29.32	89
11	8	24	56	83.78	255
12	10	20	72	80.29	244
13	4	31	67	132.56	403
14	2	17	45	45.99	140
15	9	25	48	79.63	242
16	3	21	65	78.80	240
17	1	15	45	39.27	119
18	5	7	40	14.36	44
19	7	17	55	53.41	162
20	6	17	64	60.08	183

Appendix Table 4 (continued). Canopy area and calculated dosage for each plant. The experiment evaluated 10 treatments. Each plant is an individual replication with 4 replications per treatment.

Plant #	Treatment	Radius (in.)	Height (in.)	Area (ft. sq.)	Dosage (ml.)
21	9	16	56	50.27	153
22	4	13	55	38.57	117
23	7	30	53	108.65	330
24	6	20	42	54.11	165
25	3	15	60	49.09	149
26	10	17	52	51.18	156
27	8	10	38	20.94	64
28	1	18	50	53.41	162
29	2	11	24	16.80	51
30	5	24	57	84.82	258
31	8	14	48	37.87	115
32	9	20	32	45.38	138
33	1	21	76	88.88	270
34	5	24	65	93.20	283
35	2	19	55	61.35	187
36	3	25	65	98.17	299
37	6	11	26	17.76	54
38	4	12	42	28.27	86
39	10	22	63	81.59	248
40	7	11	45	26.88	82

Appendix Table 5. Diameter (inches) measured six inches above soil grade for each plant. The experiment evaluated 11 treatments, including an untreated check. Each plant is an individual replication.

Plant	Treatment	Diameter (inches)	Plant	Treatment	Diameter (inches)	Plant	Treatment	Diameter (inches)
1	6	1.15	36	2	2.58	71	6	1.84
2	5	1.3	37	7	1.72	72	11	1.59
3	3	1.12	38	4	1.48	73	9	1.75
4	2	1	39	3	1.35	74	4	2.3
5	8	1.7	40	11	1.52	75	5	2.39
6	4	0.75	41	5	4.21	76	2	1.19
7	10	2.94	42	10	1.31	77	8	1.94
8	11	1.94	43	1	2.33	78	2	2.46
9	1	3.19	44	9	2.5	79	5	1.49
10	7	2.45	45	5	3.02	80	3	1.56
11	9	1.39	46	3	2.59	81	7	1.98
12	2	1.4	47	6	2.62	82	10	2.14
13	1	1.59	48	4	1.87	83	6	2.28
14	6	1.27	49	8	1.69	84	9	1.23
15	9	2.05	50	2	1.38	85	4	1.31
16	3	1.22	51	9	1.31	86	1	2.02
17	7	0.81	52	1	1.28	87	11	1.69
18	4	2.38	53	11	2.03	88	1	1.22
19	5	2.84	54	7	2	89	8	1.88
20	10	1.56	55	10	1.49	90	9	1.04
21	11	1.97	56	4	0.94	91	10	0.89
22	8	2.62	57	8	1.12	92	7	1.5
23	8	1.4	58	6	0.9	93	1	1.63
24	6	1.73	59	2	1.34	94	6	1.08
25	3	1.19	60	5	1.25	95	2	2.37
26	9	1.83	61	7	1.68	96	4	1.78
27	2	3.17	62	11	1.71	97	3	0.91
28	10	2.1	63	10	1.49	98	5	1.04
29	4	1.64	64	3	1.52	99	11	2.41
30	5	1.68	65	9	1.09			
31	7	2.94	66	1	2.82			
32	11	2.8	67	3	1.71			
33	1	3.34	68	10	1.53			
34	8	2.08	69	8	1.8			
35	6	2.07	70	7	1.82			

Appendix Table 6. Percent total vegetative cover for herbicide treatments at 36, 61, 133, & 153 days after treatment (DAT). The site was visually rated on June 15, July 10, September 20, & October 10, 2023. Treatments were applied May 10, 2023. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/acre	% Total Cover 6/15/23 36 DAT	% Total Cover 7/10/23 61 DAT	% Total Cover 9/20/23 133 DAT	% Total Cover 10/10/23 153 DAT
1	untreated	--	35	40	60	60
2	Method 240SL	12	0.1	0.1	3	3
1st year	Esplanade 200 SC	5				
	Arsenal Powerline	8				
	RoundUp Pro Concentrate	64				
3	TerraVue	5	0	0	0	0
1st year	Esplanade 200 SC	5				
	Arsenal Powerline	8				
	Fusilade II	24				
4	Method 240SL	16	0.1	0.1	0.1	0.1
1st year	Prodiamine 65 WDG	32				
	Arsenal Powerline	8				
	RoundUp Pro Concentrate	64				

Appendix Table 7. Percent grass cover for herbicide treatments at 36, 61, 133, & 153 days after treatment (DAT). The site was visually rated on June 15, July 10, September 20, & October 10, 2023. Treatments were applied May 10, 2023. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/acre	% Grass Cover 6/15/23 36 DAT	% Grass Cover 7/10/23 61 DAT	% Grass Cover 9/20/23 133 DAT	% Grass Cover 10/10/23 153 DAT
1	untreated	--	30	35	40	40
2	Method 240SL	12	0.1	0.1	2.9	2.9
1st year	Esplanade 200 SC	5				
	Arsenal Powerline	8				
	RoundUp Pro Concentrate	64				
3	TerraVue	5	0	0	0	0
1st year	Esplanade 200 SC	5				
	Arsenal Powerline	8				
	Fusilade II	24				
4	Method 240SL	16	0.1	0.1	0.1	0.1
1st year	Prodiamine 65 WDG	32				
	Arsenal Powerline	8				
	RoundUp Pro Concentrate	64				

Appendix Table 8. Percent broadleaf weed (BLW) cover for herbicide treatments at 36, 61, 133, & 153 days after treatment (DAT). The site was visually rated on June 15, July 10, September 20, & October 10, 2023. Treatments were applied May 10, 2023. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/acre	% BLW Cover 6/15/23 36DAT	% BLW Cover 7/10/23 61 DAT	% BLW Cover 9/20/23 133 DAT	% BLW Cover 10/10/23 153 DAT
1	untreated	--	5	5	20	20
2	Method 240SL	12	0	0	0.1	0.1
1st year	Esplanade 200 SC	5				
	Arsenal Powerline	8				
	RoundUp Pro Concentrate	64				
3	TerraVue	5	0	0	0	0
1st year	Esplanade 200 SC	5				
	Arsenal Powerline	8				
	Fusilade II	24				
4	Method 240SL	16	0	0	0	0
1st year	Prodiamine 65 WDG	32				
	Arsenal Powerline	8				
	RoundUp Pro Concentrate	64				

Appendix Table 9. Percent total vegetative cover for herbicide treatments at 0, 32, 64, 88, 127, & 151 days after treatment (DAT). The site was visually rated on May 14, June 17, July 19, August 12, September 20, & October 14, 2024. Treatments were applied May 16, 2024. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/ac	% Total Cover 5/14/24 0 DAT	% Total Cover 6/17/24 32 DAT	% Total Cover 7/19/24 64 DAT	% Total Cover 8/12/24 88 DAT	% Total Cover 9/20/24 127 DAT	% Total Cover 10/14/24 151 DAT
1	Untreated	--	40	40	50	60	65	65
2	Method 240SL	16	3	0.1	0.6	0.6	1	1.25
2nd year	Pendulum Aquacap	128						
	Arsenal Powerline	8						
	RoundUp Custom ATU	64						
3	Method 240SL	12	0.05	0	0	0	0.1	0.15
2nd year	Piper EZ	20						
	Arsenal Powerline	8						
	RoundUp Custom ATU	64						
4	Piper EZ	20	0.05	0	0	0.1	0.1	0.35
2nd year	Hyvar XL	64						
	RoundUp Custom ATU	64						

Appendix Table 10. Percent grass cover for herbicide treatments at 64, 88, 127, & 151 days after treatment (DAT). The site was visually rated on July 19, August 12, September 20, & October 14, 2024. Treatments were applied May 16, 2024. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/ac	% Grass Cover 7/19/24 64 DAT	% Grass Cover 8/12/24 88 DAT	% Grass Cover 9/20/24 127 DAT	% Grass Cover 10/14/24 151 DAT
1	Untreated	--	30	35	35	35
2	Method 240SL	16	0.1	0.1	0.75	0.75
2nd year	Pendulum Aquacap	128				
	Arsenal Powerline	8				
	RoundUp Custom ATU	64				
3	Method 240SL	12	0	0	0	0
2nd year	Piper EZ	20				
	Arsenal Powerline	8				
	RoundUp Custom ATU	64				
4	Piper EZ	20	0	0.1	0.1	0.1
2nd year	Hyvar XL	64				
	RoundUp Custom ATU	64				

Appendix Table 11. Percent broadleaf weed (BLW) cover for herbicide treatments at 64, 88, 127, & 151 days after treatment (DAT). The site was visually rated on July 19, August 12, September 20, & October 14, 2024. Treatments were applied May 16, 2024. A non-ionic surfactant was added to all treatments at 0.25% v/v.

Program	Product	Rate oz/ac	% BLW Cover 7/19/24 64 DAT	% BLW Cover 8/12/24 88 DAT	% BLW Cover 9/20/24 127 DAT	% BLW Cover 10/14/24 151 DAT
1	Untreated	--	20	25	30	30
2	Method 240SL	16	0.5	0.5	0.25	0.5
2nd year	Pendulum Aquacap	128				
	Arsenal Powerline	8				
	RoundUp Custom ATU	64				
3	Method 240SL	12	0	0	0.1	0.15
2nd year	Piper EZ	20				
	Arsenal Powerline	8				
	RoundUp Custom ATU	64				
4	Piper EZ	20	0.1	0	0	0.25
2nd year	Hyvar XL	64				
	RoundUp Custom ATU	64				