Roadside Vegetation Management Research – 2018 Report

ANNUAL REPORT

June 30, 2018

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

THE PENNSYLVANIA STATE UNIVERSITY

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16. Abstract

This report details a cooperative research project performed for the Pennsylvania Department of Transportation's Bureau of Maintenance and Operations by Penn State. The report includes the following: Comparison of Amincyclopyrachlor, Aminopyralid, and two Formulations Triclopyr for Control of Autumn Olive *(Elaeagnus umbellata)* Using Low Volume Foliar Treatments, The Effects of Commonly Used Herbicides on Spotted Knapweed *(Centaurea stoebe var. micranthos),* Evaluating Alternative Turf Growth Regulators for Seedhead Control as Part of a Broadleaf Weed Control Program, Evaluations of Seed Mixes and Seeding Methods for Overseeding Low Growing Turf Groundcover around Cable Guiderails, Comparison of Esplanade, Rimsulfuron, and Esplanade plus Rimsulfuron to Some Commonly Used Tank Mixes for Season Long Weed Control

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We are grateful for the assistance of the representatives of the various manufacturers providing products for the vegetation management industry, who have lent their time, expertise, and material support on many occasions. The following manufacturers assisted this research project during the 2017 season: Dow AgroSciences, BASF Corporation, Bayer Environmental Science, NuFarm Specialty Products, and Wilbur-Ellis Company.

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INTRODUCTION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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, EC=emulsifiable concentrate, ME=microencapsulated, RTU = ready to use, S=water soluble, SC = soluble concentrate, SG = soluble granule, SL = soluble liquid, WG, WDG=water-dispersible granules.

Trade Name	Active Ingredients	Formulation	Manufacturer
Cleantraxx	oxyfluorfen + penoxsulam	40.31 + 0.85 SC	Dow AgroSciences LLC
DMA 4 IVM	2,4-D	3.8 S	Dow AgroSciences LLC
Embark	mefluidide	2 S	PBI/Gordon Corporation
Escort XP	metsulfuron	60 DF	Bayer Environmental Science
Esplanade	indaziflam	200 SC	Bayer Environmental Science
Freelexx	2,4-D choline	3.8 S	Dow AgroSciences LLC
Garlon 3A	triclopyr amine	3 S	Dow AgroSciences LLC
IAF-RIS	indazflam + rimsulfuron	24.3 + 16.7 WDG	Bayer Environmental Science
Method 50SG	aminocyclopyrachlor	50 SG	Bayer Environmental Science
Method 240SL	aminocyclopyrachlor	2 SL	Bayer Environmental Science
Milestone VM	aminopyralid	2 S	Dow AgroSciences LLC
Oust XP	sulfmeturon	75 DG	Bayer Environmental Science
Plateau	imazapic	2 SL	BASF Corporation
Portfolio	sulfentrazone	4 F	Wilbur-Ellis Company
Rezilon	rimsulfuron	25 SG	Bayer Environmental Science
Roundup Pro	glyphosate	5 S	Monsanto Company
Segment	sethoxydim	1 S	BASF Corporation
Triplet LO	2,4-D+mecoprop-p +dicamba	47.3 +8.2 + 2.3 S	Nufarm Americas, Inc.
Vastlan	triclopyr choline	4 S	Dow AgroSciences LLC

COMPARISON OF AMINOCYCLOPYRACHLOR, AMINOPYRALID, AND TWO FORMULATIONS OF TRICLOPYR FOR CONTROL OF AUTUMN OLIVE *(Elaeagnus umbellata)* USING LOW VOLUME FOLIAR TREATMENTS

<u>Herbicide trade and common names:</u> Milestone VM *(aminopyralid);* Method 240 SL *(aminocyclopyrachlor)*; Method 50 SG *(aminocyclopyrachlor)*; Garlon 3A *(triclopyr)*; Vastlan *(triclopyr choline)*
<u>Plant common and scientific names:</u> autumn olive *(Elaeagnus umbellata)*

ABSTRACT

Autumn olive ranks among the difficult to control brush species found along the roadside in Pennsylvania. An experiment was conducted at the Penn State Agronomy Farm located at the Russell E. Larson Agricultural Research Center near Rock Springs, PA to compare several herbicides for control of autumn olive. The experiment evaluated the performance of Milestone VM, Method 50 SG, Garlon 3A, Vastlan, and Method 240 SL. Treatments included Method 240 SL at 4.8 oz/ac, 9.6 oz/ac, and 19.2 oz/ac; Milestone VM at 4.8 oz/ac and 9.6 oz/ac; Method 50 SG at 4.8 oz/ac; Garlon 3A at 128 oz/ac; Vastlan at 96 oz/ac; and an untreated check. Methylated seed oil, FS MSO Ultra, at 1% v/v was added to all herbicide treatments. The treatments were applied at a carrier volume of 15 gallons per acre, GPA. The amount of herbicide applied was based on the calculated canopy area of the plants in that treatment. Initial percent control of autumn olive ranged from 18% to 98.3% 34 DAT (days after treatment). By 393 DAT, the range of percent control of autumn olive (1.3% to 73%) decreased dramatically compared to earlier dates. Garlon 3A at 128 oz/ac and Vastlan at 96 oz/ac provided moderate control of autumn olive 1 year after treatment. Method 240 SL at 4.8 oz/ac, 9.6 oz/ac, and 19.2 oz/ac; Method 50 SG at 4.8 oz/ac; and Milestone at 4.8 oz/ac and 9.6 oz/ac provided unacceptable control of autumn olive 1 year after treatment.

INTRODUCTION

Autumn olive (Elaeagnus umbellata) is a problematic brush species once established in a roadside ROW. After mowing or cutting autumn olive, it will vigorously resprout, spreading and crowding out desirable vegetation which can reduce visibility for motorists and impede maintenance operations. Autumn olive has characteristics which make it a formidable pest. Plants can reach 11 feet in height, fruit prolifically with birds dispersing the seeds beyond the immediate area. Elaeagnus is a nitrogen fixing non-native shrub, which aids its establishment to grow in poor soil conditions found along the roadside.

MATERIALS AND METHODS

The experiment was established at the Penn State Agronomy Farm at the Russell E. Larson Agricultural Research Center. Treatments included Method 240 SL at 4.8 oz/ac, 9.6 oz/ac, and 19.2 oz/ac; Milestone VM at 4.8 oz/ac and 9.6 oz/ac; Method 50 SG at 4.8 oz/ac; Garlon 3A at 128 oz/ac; Vastlan at 96 oz/ac; and an untreated check. The active ingredient in Method 240 SL is ½ the rate of Method 50 SG (for example 4 oz of Method 240 SL is equivalent to 2 oz of Method 50 SG). Methylated seed oil, FS MSO Ultra, at 1% v/v was added to all herbicide treatments. The application was made at a carrier volume of 15 gallons per acre, GPA.

The amount of herbicide applied was based on the calculated canopy area of the plants in that treatment. The canopy measurements can be found in Table 1. Autumn olive selected for the trial had a maximum height of 128 inches, a minimum height of 28 inches and averaged 64 inches tall. The experiment was established with 10 plants per treatment for a total of 90 plants arranged in a completely randomized design. Treatments were applied using a CO_2-powered sprayer equipped with an AA30 GunJet 30 spray gun, TeeJet adjustable ConeJet nozzle, and Y-2 tip operating at 36 psi. The autumn olive was treated on August 9, 2016.

Percent control (0 = no injury, 100 = complete necrosis) of autumn olive was visually rated on September 12, 2016, October 17, 2016 and September 6, 2017; 34, 69, and 393 DAT (days after treatment) respectively. All data was subject to analysis of variance, and when treatment effect F test were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Initial control of autumn olive ranged from 18% to 98.3% 34 DAT. Similar percent control (17.5% to 98.9%) was observed at 69 DAT. All treatments showed lower percent control (1.3% to 73%) by 393 DAT. The triclopyr formulations, Garlon 3A (amine) or Vastlan (choline), were the most effective treatments throughout the experiment. At 393 DAT, Vastlan resulted in the best control at 73% while Garlon 3A produced 60.5% control. The least effective treatment was Milestone at 9.6 oz/ac with 1.3% control. Method 50 SG at 4.8 oz/ac consistently outperformed Method 240 SL at 9.6 oz/ac. This is intriguing in that the active ingredient rate is the same for Method 240 SL at 9.6 oz/ac and Method 50 SG at 4.8 oz/ac, however the inert ingredients are different. Milestone at 4.8 oz/ac was consistently more effective than Milestone at 9.6 oz/ac. Overall trends for all herbicide treatments include: an increase in percent control from 34 DAT to 69 DAT and decrease in percent control from 69 DAT to 393 DAT. In general, autumn olive plants resprouted by 393 DAT resulting in decreased control from the treatment a year earlier.

CONCLUSIONS

Increasing Method 240 SL rates from 4.8 oz/ac to 19.6 oz/ac increased percent control of autumn olive. Milestone at 4.8 oz/ac was more effective than Milestone at 9.6 oz/ac. Garlon 3A at 128 oz/ac and Vastlan 96 oz/ac were more effective than Method 240 SL, Milestone, and Method 50 SG. Further research at different carrier rates and with additional herbicides should be conducted to determine effective control treatments for autumn olive.

MANAGEMENT IMPLICATIONS

Of the products tested, Garlon 3A at 128 oz/ac and Vastlan at 96 oz/ac provided marginal control of autumn olive 1 year after treatment at the low carrier volume used in this experiment. Method 240 SL at 4.8 oz/ac, 9.6 oz/ac, and 19.2 oz/ac; Method 50 SG at 4.8 oz/ac; and Milestone at 4.8 oz/ac and 9.6 oz/ac provided unacceptable control of autumn olive 1 year after treatment. Caution should be used when using products that contain aminocyclopyrachlor due to soil activity and potential injure to nearby desirable trees. Also, caution should be exercised when using aminopyralid due to the potential injury to nearby leguminous trees and shrubs as well as other species listed on the label or supplemental literature from DOW AgroSciences.

Table 1. Stem canopy area and height of plant. Each plant is an individual treatment for a total of 9 treatments. Each treatment was replicated 10 times.

Stem No.	Treatment	Area (sq.)	Height (in.)	Stem No.	Treatment	Area (sq.)	Height (in.)
1	2	7	72	46	7	15	70
2	8	2	33	47	3	18	92
3	9	7	61	48	9	24	72
4	3	3	62	49	1	5	58
5	6	16	66	50	8	20	92
6	1	7	56	51	4	6	74
7	7	6	46	52	6	2	35
8	4	13	72	53	5	14	110
9	5	1	38	54	2	8	54
10	6	10	46	55	4	11	72
11	7	1	75	56	5	12	78
12	8	15	128	57	2	8	78
13	2	3	46	58	6	8	92
14	9	3	46	59	3	4	50
15	1	49	102	60	7	1	46
16	5	14	58	61	1	15	74
17	4	27	70	62	8	5	108
18	3	7	94	63	9	2	48
19	4	11	60	64	9	9	102
20	1	29	92	65	4	8	70
21	9	7	50	66	6	13	92
22	7	6	66	67	8	24	72
23	2	4	40	68	2	4	86
24	8	9	46	69	5	7	98
25	5	4	34	70	7	14	72
26	6	15	92	71	3	11	68
27	3	26	112	72	1	2	40
28	2	14	56	73	7	5	68
29	5	27	76	74	1	6	62
30	1	20	84	75	6	8	35
31	9	6	34	76	2	3	36
32	3	11	74	77	8	3	32
33	7	9	102	78	5	1	38
34	6	10	82	79	9	7	62
35	8	9	78	80	3	9	40
36	4	9	50	81	4	2	50
37	4	6	60	82	1	11	54
38	1	4	36	83	3	11	42
39	5	4	38	84	5	6	74
40	2	4	35	85	9	6	33
41	3	15	108	86	2	7	34
42	6	9	44	87	7	7	54
43	7	3	60	88	4	11	74
44	9	4	28	89	8	2	66
45	8	3	56	90	6	8	54

Table 2: Percent injury and control was visually rated as percent defoliation of autumn olive. Treatments were applied August 9, 2016 at 15 GPA. All treatments included methylated seed oil, FS MSO Ultra at 1 % v/v. Percent injury of autumn olive was visually rated on September 12, 2016 and October 17, 2016; 34 and 69 DAT (days after treatment) respectively. Percent control of autumn olive was visually rated on September 6, 2017; 393 DAT. Each value is the mean of ten replications. Means within columns followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Rate oz/ac	Percent Injury 34 DAT	Percent Injury 69 DAT	Percent Control 393 DAT
Untreated	--	0 a	0 a	0.2 a
Method 240 SL	4.8	39.5 bc	47 bc	32.2 ab
Method 240 SL	9.6	19.5 ab	35 abc	28.9 ab
Method 240 SL	19.2	61 cd	63.5 cd	42 ab
Milestone VM	4.8	36.5 abc	41 bc	33.5 ab
Milestone VM	9.6	18 ab	17.5 ab	1.3 a
Method 50 SG	4.8	53 bc	64.5 cd	34.5 ab
Garlon 3A	128	98.3 e	98.9 d	60.5 b
Vastlan	96	92.5 de	94.8 d	73 b

THE EFFECTS OF COMMONLY USED HERBICIDES ON SPOTTED KNAPWEED
(*Centaurea stoebe var. micranthos)*

Herbicide trade and common chemical names: Method 240 SL *(aminocyclopyrachlor),* Method 50 SG *(aminocyclopyrachlor),* Garlon 3A *(triclopyr amine),* Vastlan *(triclopyr choline),* DMA 4 IVM *(2,4-D),* Freelexx (*2,4-D choline*), Milestone VM (*aminopyralid*)

Plant common and scientific names: Spotted Knapweed (*Centaurea stoebe var. micranthos, CESTM synonym C. maculosa,* CETMA)

ABSTRACT

Spotted knapweed outcompetes native plant species as well as desirable roadside vegetation. This experiment evaluated herbicides and herbicide combinations. The treatments were 64 oz/ac DMA 4 IVM plus 64 oz/ac Garlon 3A; 64 oz/ac Freelexx plus 64 oz/ac Garlon 3A; 64oz/ac DMA 4 IVM plus 48 oz/ac Vastlan; 8 oz/ac Method 240 SL; 4 oz/ac Method 50 SG; and 7 oz/ac Milestone. The most effective results in this experiment were 8 oz/ac Method 240 SL, 64 oz/ac DMA 4 IVM plus 64 oz/ac Garlon 3A, and 7 oz/ac Milestone. Spotted knapweed was found covering 45-67.5% of the treatment area. All herbicide treatments were effective in injuring spotted knapweed one month after treatment with 66-96% injury. Of all of the treatments Method 50SG and 240SL demonstrated the greatest injury at 96-99%. By two months after treatment all treatments except DMA 4IVM and Vastlan recorded rosette coverage of 0.1 to 9% of the treatment plots representing a decrease in coverage from 60 to 36%, respectively among treatments.

INTRODUCTION

Spotted knapweed is a Eurasian introduced biennial to short lived perennial invasive plant found throughout the United States and Canada and is becoming increasingly common on the roadsides of Pennsylvania. Spotted knapweed is typically found in full sun on dry, gravelly, or sandy sites, especially following disturbance. Colonization is aided by long seed viability and heavy seed production averaging 1,000 to 5,000 seeds per plant.[1,2] Spotted knapweed has the potential to establish, spread, and reduce native plant populations. One of the reasons that spotted knapweed is able to compete so effectively with native vegetation is that it is reported to have allelopathic characteristics that include the ability to exude catechin a phenolic secondary metabolite from its root system that will effectively act as an herbicide to native plants or existing ground covers.[3] This experiment was initiated to evaluate herbicides and herbicide tank mixes for effectiveness in controlling spotted knapweed.

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[1] Spotted Knapweed https://mdc.mo.gov/sites/default/downloads/9530_6467.pdf Viewed 2/13/2018

[2] Spotted Knapweed http://paflora.org/original/pdf/INV-Fact%20Sheets/Centaurea%20maculosa.pdf Viewed 2/1/18

METHODS AND MATERIALS

The experiment was established on the shoulder of the entrance ramp to SR 322 W at Old Fort, just east of State College, PA. Six herbicide treatments were tested including: 64 oz/ac DMA 4 IVM plus 64 oz/ac Garlon 3A; 64 oz/ac Freelexx plus 64 oz/ac Garlon 3A; 64oz/ac DMA 4 IVM plus 48 oz/ac Vastlan; 8 oz/ac Method 240 SL; 4 oz/ac Method 50 SG; 7 oz/ac Milestone; and an untreated check. All herbicide treatments included a non-ionic surfactant at 0.25percent v/v. Plots of 20 by 6 feet were arranged in a randomized complete block design with four replications. Herbicides were applied at 30 gallons per acre on July 7, 2017 using a CO_2 powered backpack sprayer with a 6-foot boom equipped with 4 8002 VS nozzles. Initial percent spotted knapweed cover was recorded on July 7,2017 on day of treatment. The percent spotted knapweed injury was recorded one month after treatment (1 MAT) on August 8,2017 . The percent cover by spotted knapweed rosettes was recorded two months after treatment (2 MAT) on September 9, 2017. All data were subject to analysis of variance, and when treatments affect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

On September 19, 2017, soil on one half of each plot was loosened with a disc harrow pulled by a Kubota tractor, formula L seed was broadcast seeded at 48 oz/1000 sq. yd to determine the effect of a competitive ground cover on controlling spotted knapweed. The seeded plots were fertilized according to soil test recommendations at 1lb N per 1000 sq. ft., and straw blankets were rolled out over the area and secured.

RESULTS AND DISCUSSION

The initial spotted knapweed percentage cover ranged from 45 to 67.5 percent with no significant differences between treatment plots (Table 1). The percent injury rating recorded on August 8, 2017 (1 month after treatment, 1 MAT), ranged from 66 to 99 percent. Method 240 SL applied at 8 oz/ac and Method 50 SG applied at 4 oz/ac provided the highest level of injury to spotted knapweed at 99 and 96 percent, respectively. The September 9, 2017 rating (2 MAT) on the percent spotted knapweed rosette cover within each treatment plot showed the lowest cover among the Method treatments (Method 240SL and 50SG at 0.1, 0.4, respectively) followed by Milestone (2%), and DMA4 IVM plus Garlon 3A and Freelexx plus Garlon 3A at 9% cover. The difference in cover during the 2017-growing season is comparison between the number of flowering stems present at the start of the experiment and the number of rosettes present on September 9. Method 240 SL at 8 oz/ac, DMA 4 IVM at 64 oz/ac plus Garlon 3A at 64 oz/ac and Milestone at 7 oz/ac all produced a reduction in percent cover between -57 and - 60. DMA 4 IVM at 64 oz/ac plus Vastlan at 48 oz/ac produced the smallest reduction in percent cover (-27) of any of the chemical treatments.

MANAGEMENT IMPLICATIONS

The herbicide treatments Method 240 SL, Method 50 SG, DMA 4 IVM plus Garlon 3A, and Milestone provided good control of spotted knapweed. We recommend that managers establish turf or appropriate competitive ground cover to limit seed germination and re-establishment of spotted knapweed. With this recommendation in mind and the residual control offered by the Method based products, managers may find it helpful to consider whether choosing the DMA 4 IVM plus Garlon 3A treatment may aid in better vegetation re-establishment after treatment. The seeding project alluded to earlier in the report may provide better guidance in the coming years.

Table 1: Percent cover and injury to spotted knapweed (*Centaurea stoebe var. micranthos* CETMA). The experiment was visually rated for initial cover and treatments were applied on July 7, 2017. Percent knapweed injury was visually rated August 8, 1 month after treatment, MAT. Percent cover by knapweed rosettes was visually rated September 9, 2017, 2 MAT. All treatments included 0.25% v/v non-ionic surfactant (i.e. Induce). Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

	Knapweed				
Treatment	Rate oz/ac	% Initial cover knapweed 7/7/17	% Injury 8/8/17	% Cover knapweed rosettes 9/19/17	Difference in knapweed cover
Untreated		48	10 a	46 b	- 2
Milestone	7	59	65 b	2 a	- 57
DMA 4 IVM Vastlan	64 48	52	67 b	24 ab	-18
DMA 4 IVM Garlon 3A	64 64	68	76 b	9 a	- 59
Freelexx Garlon 3A	64 64	45	80 b	9 a	- 36
Method 50SG	4	48	96 b	0.4 a	-47.6
Method 240SL	8	60	99 b	0.1 a	- 59.9
		n.s.			

EVALUATING ALTERNATIVE TURF GROWTH REGUALTORS FOR SEEDHEAD CONTROL AS PART OF BROADLEAF WEED CONTROL PROGRAM

Herbicide trade and common names: Embark 2S (*mefluidide*), Escort XP (*metsulfuron*), Esplanade 200 SC (*indaziflam*), Method 240SL (*aminocyclopyrachlor*), Plateau (*imazapic*), Segment (*sethoxydim*).
Plant common and scientific names: Kentucky blue grass (*Poa pratensis*, POAPR), tall fescue (*Festuca arundinacea*, FESAR).

ABSTRACT

A spring application of a turf growth regulator (TGR) combined with a broadleaf herbicide can suppress tall fescue seedheads, restrict the height of turf grass, and prevent the growth of broadleaf weeds. These factors can enhance the appearance of roadside turf while reducing the necessity for mowing during the most rapid period of turf growth. This approach is especially useful in areas where mowing is difficult or dangerous due to terrain, traffic patterns, or the existence of structures such as cable guiderails. Embark, which has been the standard TGR product is no longer available except for existing inventory.[2] This experiment was designed to evaluate alternative TGRs in this situation as part of a broadleaf weed control program at two different sites in central Pennsylvania (e.g., Old Fort and Port Matilda). Treatments included Plateau at 2 or 3 oz/ac plus Method 240 SL at 10 oz/ac; Plateau at 2 or 3 oz/ac plus Escort XP at 0.2 oz/ac plus Method 240 SL at 10 oz/ac; Esplanade 200 SC at 3.5 oz/ac plus Method 240 SL at 10 oz/ac; Plateau at 2 oz/ac plus Esplanade 200 SC at 3.5 oz/ac plus Method 240 SL at 10; Escort XP at 0.33 oz/ac plus Esplanade SC at 3.5 oz/ac plus Method 240 SL at 10 oz/ac; Segment at 8, 12, or 14 oz/ac plus Method 240 SL at 10 oz/ac; Embark at 6 oz/ac plus Escort XP at 0.2 oz/ac plus Method 240 SL at 10 oz/ac; and an untreated check. All chemical treatments included a non-ionic surfactant at 0.25% v/v. Responsiveness of targeted turf varied between sites due to the broad environmental differences found at each site. The Port Matilda site was a dry, upland, full sun, and exposed site, whereas, the Old Fort site was a low land site with moist soil, protected from exposure, and with indirect sunlight. Plateau at 2 oz/ac plus Method at 10 oz/ac performed well with adequate seedhead suppression and a relatively low level of phytotoxicity. Esplanade, when combined with Plateau at 2 oz/ac and Method 240 SL at 10 oz/ac contributed little to seedhead suppression but slightly increased turf phytotoxicity. Segment at 8 oz/ac plus Method 240SL at 10 oz/ac was weak on seedhead suppression of tall fescue and at rates of 12 and 14 oz/ac plus Method 240 SL at 10 oz/ac turf phytotoxicity was observed.

INTRODUCTION

Turf growth regulators, TGRs, combined with broadleaf herbicides are used by the Pennsylvania Department of Transportation, Penn DOT, to reduce mowing cycles by suppressing turf grass growth while controlling unwanted broadleaf weeds. This approach is meant as a cost effective alternative to adding mowing cycles in the spring when the cool season grasses are undergoing rapid growth. TGR applications are often made where mechanical operations are difficult due to steep terrain, traffic hazards, or obstacles. The standard TGR mix

[2] PBI Gordon. http://pbigordonturf.com/labels.php. February 8, 2018

contained Embark, Escort XP, plus a broadleaf weed control component. In April 2015 PBI-Gordon announced the discontinuation of Embark due to the inability to locate a producer to supply the active ingredient mefluidide. In an effort to find an alternative TGR, Plateau, Esplanade, Escort XP, and Segment were compared to the standard. Plateau is labeled for the growth regulation of cool season roadside turf grass species (e.g., K-31 tall fescue and "wildtype" Kentucky bluegrass) at rates of 2 to 4 oz/ac[3]. Precautions on the label limit the use of surfactants and offer a very short list of turf species tolerant to the products. Escort XP is labeled for the suppression and seed head inhibition of well established fescue and bluegrass turf species at rates of 0.25 to 0.5 oz/ac with several precautions listed.[4] Segment is older chemistry labeled for turf growth suppression on commercial lawns or roadsides.[5] This experiment compares these alternative TGR products in combination with Method, a broadleaf product with pre and post emergence qualities at two separate locations within central Pennsylvania.

MATERIALS AND METHODS

The experiments were conducted at two locations in central Pennsylvania with unique and different environmental conditions. The first site located along the eastern shoulder of the ramp onto SR322 westbound near Old Fort was a low land site of limited exposure, moist conditions, and readily available soil. The second site located on the SR 322 westbound shoulder north of the Flat Rock exit near Port Matilda, PA was upland, drier, gravel based, and more exposed to sun and wind. Plots were 20 feet by 6 feet and were arranged as a randomized complete block design with four replications. Treatments included Plateau at 2 or 3 oz/ac plus Method 240 SL at 10 oz/ac; Plateau at 2 or 3 oz/ac plus Escort XP at 0.2 oz/ac plus Method 240 SL at 10 oz/ac; Esplanade 200 SC at 3.5 oz/ac plus Method 240 SL at 10 oz/ac; Plateau at 2 oz/ac plus Esplanade 200 SC plus Method 240 SL at 10; Escort XP at 0.33 oz/ac plus Esplanade SC at 3.5 oz/ac plus Method 240 SL at 10 oz/ac; Segment at 8, 12, or 14 oz/ac plus Method 240 SL at 10 oz/ac; Embark at 6 oz/ac plus Escort XP at 0.2 oz/ac plus Method 240 SL at 10 oz/ac; and an untreated check. Induce, a nonionic surfactant (NIS) at 0.25% v/v was added to all treatments at Old Fort. CWC surfactant 90 was the surfactant used at the Port Matilda site. The experiment was initiated on May 3 and May 8, 2017 at Old Fort and Port Matilda, respectively. Treatments were applied on May 4 and May 9, 2017, respectively at carrier rates of 35 gallons per acre using a CO_2 powered backpack sprayer equipped with a six-foot boom and four 8004 VS nozzles.

Trials were evaluated at two week intervals for percent seedhead suppression of tall fescue, average height of tall fescue, and phytotoxicity to the turf grass. Percent total turf grass cover at the beginning and completion of the experiment were evaluated as well. Past research has suggested that Kentucky bluegrass seed heads do not rise to heights that warrant concern and are a less likely target for control.[6] However, tall fescue seed heads do rise to heights that warrant control.

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[3] Plateau, BASF Corporation, Research Triangle Park, NC.
[4] Escort XP, Bayer Environmental Science, Research Triangle Park, NC.
[5] Segment, BASF Corporation, Research Triangle Park, NC.
[6] Johnson, J.M. et al 2017. Further Investigation of Alternatives to Embark 2S for Plant Growth Regulation of Roadside Turf. Roadside Vegetation Management Research – 2017 Report. pp 25-35.

At the Old Fort site, treatments were applied May 4, 2017. Data was recorded for average height of tall fescue and Kentucky bluegrass on May 3, May 18, June 1, June 15, June 30, July 13, and July 28 (0, 2, 4, 6, 8, 10 and 12 weeks after treatment, WAT)., Percent seedhead suppression of tall fescue and phytotoxicity were recorded on May 18, June 1, June 15, June 30, and July 13 (2, 4, 6, 8, and 10 WAT). Percent seedhead suppression is a measure of how much the cover by seedheads was suppressed compared to untreated plots. Phytotoxicity of the turf grass was rated on a scale from 0 to 10 where 0 equals healthy, green; 5 equals moderate discoloration; and 10 equals completely necrotic, brown. Percent turf grass cover was visually rated at the beginning (May 3) and completion (July 28) of the experiment (0 and 12 WAT).

At the Port Matilda site, treatments were applied on May 9, 2017. The trial was measured for average height of tall fescue on May 8, May 23, June 6, June 20, July 10, and July 20 (0, 2, 4, 6, 8, and 10 weeks after treatment, WAT). Percent seedhead suppression for tall fescue and phytotoxicity of turf grass were visually recorded on May 23, June 6, June 20, July 10, and July 20 (2, 4, 6, 8, and 10 WAT). Percent seedhead suppression is a measure of how much the cover by seedheads was reduced compared to untreated plots. Phytotoxicity of the turf grass was rated on a scale from 0 to 10 where 0 equals healthy, green; 5 equals moderate discoloration; and 10 equals completely necrotic, brown. Percent turf grass cover was visually rated at the beginning (May 8) and completion (July 28) of the experiment (0 and 12 WAT).

For each site, the change in turf grass cover was calculated by subtracting the initial percent turf grass cover from the final percent turf grass cover. Tables showing complete data for all rating dates are located in the appendix. All data were subject to analysis of variance, and when treatments effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSIONS

At the Old Fort site, treatments were uniformly effective at inhibiting seedheads on tall fescue turf (93 to 99 percent reduction at 10 weeks after treatment, WAT) with the exception of Esplanade at 3.5 oz/ac plus Method 240SL at 10 oz/ac which produced a 56.3 percent reduction at 10 WAT) (Table 2). Tall fescue height across treatments was similar at 6 WAT with the only 2 treatments yielding turf significantly shorter than the control being Segment at 8 oz/ac plus Method at 10 oz/ac and plateau at 2 oz/ac plus Method 240 SL at 10 oz/ac (10.6 and 10.7 inches, respectively) (Table 1). By 10 WAT tall fescue in all treatments including the untreated control was statistically similar in height ranging from 12.3 to 14.6 inches. We have found in previous experiments that growth resumes at 10 WAT. [7] Rainfall in State College, PA during June 2017 was only 0.65 in., which may have reduced turf growth across all treatments.[8] Turf phytotoxicity often is at its worst several weeks after application of the treatments.[5] At 4 WAT, plots treated with Segment at 12 and 14 oz/ac plus Method at 10 oz/ac and plots treated with plateau at 2 oz/ac plus Esplanade 200 SC at 3.5 oz/ac plus Method 240 SL at 10 oz/ac showed the highest levels of turf phytotoxicity ranging from 4.5 to 5.3 (Table 4). Past experiments demonstrated

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[7] Johnson, J.M. et al 2017. Further Investigation of Alternatives to Embark 2S for Plant Growth Regulation of Roadside Turf. Roadside Vegetation Management Research – 2017 Report. pp 25-35.

[8] Weather Underground Historical Data. https://www.wunderground.com/February 8, 2018.

that turf phytotoxicity injury is most severe between 2 WAT and 4 WAT. Change in percent cover from beginning to end of the experiment is designed to evaluate thinning of the turf caused by the TGR treatments. At the Old Fort site only one treatment, Segment at 8 oz/ac plus Method 240 SL at 10 oz/ac caused a decrease in turf cover, a change in percent cover of -5 (Table 3).

At the Port Matilda site, tall fescue height across chemical treatments was statistically similar at 6 WAT with Plateau at 2 oz/ac plus Escort XP at 0.2 oz/ac plus Method 240 SL at 10oz/ac providing the best height control at 10.2 inches (Table 5). At 10 WAT no herbicide treatments were significantly different from the controls. All treatments, except Esplanade 200 SC 3,5 oz/ac plus Method 240 SL at 10 oz/ac and Segment at 8 oz/ac plus Method 240 SL at 10 oz/ac, provided excellent seed head suppression of tall fescue ranging from 95-100 percent at 6 and 10 WAT (Table 6). Turf phytotoxicity was relatively low at Port Matilda (3.5 or less) and the most severe levels occurred early in the study. At 4 WAT, Embark at 6 oz/ac plus Escort XP at 0.2 oz/ac plus Method 240 SL at 10 oz/ac produced a phytotoxicity level of 3 and Segment at 14 oz/ac plus Method 240 SL at 10 oz/ac produced a rating of 3.3 (Table 8). For the remainder of the experiment, ratings did not exceed 1.0. Initial percent turf grass cover was similar for all treatments including the untreated check and ranged from 50 percent to 55 percent. All chemical treatments showed a decrease in percent turf grass cover over the course of the experiment (ranging from -1 to -9) except Plateau at 2 oz/ac plus Escort XP 0.2 oz/ac plus Method 240 SL at 10 oz/ac which produced no change in turf grass cover (Table 7). At the end of the experiment (11 WAT), turf grass cover for the untreated check plots increased 9 percent when compared to the initial rating.

CONCLUSIONS

Plateau at 2 oz/ac plus Method at 10 oz/ac performed produced acceptable seedhead suppression and a relatively low level of phytotoxicity. Past work has shown that adding Escort to the mix or increasing the Plateau rate to 3 oz/ac has the potential to increase turf phytotoxicity without the benefit of greater seedhead suppression.[9] Esplanade, when combine with Plateau at 2 oz/ac and Method 240 SL at 10 oz/ac contributed little to seedhead suppression but slightly increased turf phytotoxicity. Segment at the highest rate tested (14 oz/ac) produced the highest level of phytotoxicity demonstrated at either site. Segment at 8 oz/ac plus Method at 10 oz/ac did not cause turf phytotoxicity beyond that caused with most other treatments, however the results on seedhead suppression with Segment at 8 oz/ac were mixed between the two sites. The Port Matilda site is on higher ground with sandy soil and situated on a greater slope, which contribute to making the site more prone to drought stress. At Port Matilda, most tank mixes tested also caused a decrease in turf cover during the experiment while at Old Fort all but one treatment resulted in an increase in turf cover.

[9] Johnson, J.M. et al 2017. Further Investigation of Alternatives to Embark 2S for Plant Growth Regulation of Roadside Turf. Roadside Vegetation Management Research – 2017 Report. pp 25-35.

MANAGEMENT IMPLICATIONS

Except for existing inventory, Embark is no longer available as a TGR option. As stated in previous studies and confirmed with this experiment, Plateau at rates of 2 oz/ac plus Method 240 SL at 10 oz/ac offers an alternative tank mix. Additionally, Segment at 8 oz/ac plus Method 240 SL at 10 oz/ac shows some promise. However, Segment at 8 oz/ac shows inconsistent seedhead suppression of tall fescue but at rates of 12 or 14 oz/ac turf phytotoxicity becomes an issue. A spring application of a labeled TGR, just prior to seedhead emergence, appears to prevent development of seedheads of tall fescue. With a properly timed application the number of mowing cycles can be reduced in areas were mechanical operations are difficult or dangerous. Caution should be used when adding Method as this product is soil active and has potential to kill desirable trees. As always, read and follow the label instructions prior to planning for and making applications.

Table 1: Average height of the tall fescue stand at Old Fort. The measured tall fescue height on June 15 and July 13, 2017 (6 and 10 weeks after treatment, WAT). Treatments were applied on May 4, 2017. All treatments included 0.25% v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	Rate oz/ac	Tall Fescue Average Height (Inches)	
		6 WAT	10 WAT
Untreated	--	14.1 b	13.8 a
Segment Method 240 SL	8 10	10.6 a	12.3 a
Segment Method 240 SL	14 10	11.6 ab	13.4 a
Segment Method 240 SL	12 10	12.3 ab	14.6 a
Plateau Method 240 SL	3 10	12.3 ab	13.5 a
Plateau Escort XP Method 240 SL	3 0.2 10	11.9 ab	13.7 a
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	13.3 ab	13.9 a
Plateau Method 240 SL	2 10	10.7 a	13.3 a
Plateau Escort XP Method 240 SL	2 0.2 10	12.2 ab	12.8 a
Esplanade 200 SC Method 240 SL 10	3.5 10	12.3 ab	14.6 a
Escort XP Esplanade 200 SC Method 240 SL	0.33 3.5 10	11.3 ab	12.9 a
Embark 2S Escort XP Method 240 SL	6 0.2 10	11.9 ab	12.3 a

Table 2: Percent seedhead suppression of the tall fescue stand at Old Fort. The treatments were visually rated for seedhead suppression of tall fescue on June 15 and July 17 (6 and 10 weeks after treatment, WAT). Treatments were applied on May 4, 2017. All treatments included 0.25% v/v non-ionic surfactant. Seedhead suppression was not rated for control plots. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	Rate oz/ac	Percent Tall Fescue Seedhead Suppression 6 WAT	Percent Tall Fescue Seedhead Suppression 10 WAT
Untreated	--	-	-
Segment Method 240 SL	8 10	93.8 b	94.8 b
Segment Method 240 SL	14 10	98.5 b	98.5 b
Segment Method 240 SL	12 10	97.3 b	97.3 b
Plateau Method 240 SL	3 10	98.5 b	98.5 b
Plateau Escort XP Method 240 SL	3 0.2 10	99.8 b	99.8 b
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	97.5 b	97.3 b
Plateau Method 240 SL	2 10	96.3 b	96.3 b
Plateau Escort XP Method 240 SL	2 0.2 10	99.3 b	99.3 b
Esplanade 200 SC Method 240 SL	3.5 10	50 a	56.3 a
Escort XP Esplanade 200 SC Method 240 SL	0.33 3.5 10	99.5 a	99.5 b
Embark 2S Escort XP Method 240 SL	6 0.2 10	93.3 b	93.3 b
Seedhead suppression control plots not rated			

Table 3: Percent cover of turf grass stand at Old Fort. The treatments were visually evaluated for turf cover on May 3 and July 28, 2017 (0 and 12 weeks after treatment, WAT). The percent change in turf cover is the difference between 12 WAT ratings and 0 WAT ratings. Treatments were applied May 4, 2017. All treatments included 0.25% v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	Rate oz/ac	Percent Turf Cover		Change in Turf Cover
		0 WAT	12 WAT	12 WAT
Untreated	--	63	79	16
Segment Method 240 SL	8 10	56	51	-5
Segment Method 240 SL	14 10	61	66	5
Segment Method 240 SL	12 10	60	65	5
Plateau Method 240 SL	3 10	63	64	1
Plateau Escort XP Method 240 SL	3 0.2 10	59	64	5
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	60	66	6
Plateau Method 240 SL	2 10	60	64	4
Plateau Escort XP Method 240 SL	2 0.2 10	60	74	14
Esplanade 200 SC Method 240 SL	3.5 10	58	65	7
Escort XP Esplanade 200 SC Method 240 SL	0.33 3.5 10	63	63	0
Embark 2S Escort XP Method 240 SL	6 0.2 10	61	73	12

Table 4: Phytotoxicity of the turf grass stand at Old Fort. The treatments were visually evaluated for turf grass phytotoxicity using a scale of 0-10 where “0” = healthy, green; “5” = moderate discoloration; “10” = completely necrotic, brown. Evaluations were made on June 1 and July 17 (4 and 10 weeks after treatment, WAT). Treatments were applied on May 4, 2017. All treatments included 0.25% v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	Rate oz/ac	Turf grass Phytotoxicity (0-10) Scale	
		4 WAT	10 WAT
Untreated	--	0 a	0 a
Segment Method 240 SL	8 10	2.3 abc	1.3 abc
Segment Method 240 SL	14 10	5.3 c	1 abc
Segment Method 240 SL	12 10	4.5 bc	1 abc
Plateau Method 240 SL	3 10	2.8 abc	1 abc
Plateau Escort XP Method 240 SL	3 0.2 10	3 abc	0.5 ab
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	5 c	2.3 c
Plateau Method 240 SL	2 10	2.8 abc	0.8 ab
Plateau Escort XP Method 240 SL	2 0.2 10	2.5 abc	0.8 ab
Esplanade 200 SC Method 240 SL	3.5 10	1.3 ab	0.8 ab
Escort XP Esplanade 200 SC Method 240 SL	0.33 3.5 10	3.8 bc	1.5 bc
Embark 2S Escort XP Method 240 SL	6 0.2 10	2 abc	0.5 ab

Table 5: Average height of the tall fescue stand at Port Matilda. The experiment was measured for tall fescue height on June 20 and July 20, 2017 (6 and 10 weeks after treatment, WAT). Treatments were applied on May 9, 2017. All treatments included 0.25% v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	Rate oz/ac	Tall Fescue Average Height (Inches)	
		6 WAT	10 WAT
Untreated	--	15.8 c	14.8
Segment Method 240 SL	8 10	12.9 abc	15
Segment Method 240 SL	14 10	12.9 abc	16.5
Segment Method 240 SL	12 10	13 abc	15.3
Plateau Method 240 SL	3 10	12.1 ab	17.2
Plateau Escort XP Method 240 SL	3 0.2 10	11.8 ab	15.3
Plateau Method 240 SL	2 10	12.3 ab	15.5
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	12.8 ab	16.2
Plateau Escort XP Method 240 SL	2 0.2 10	10.2 a	16.2
Esplanade 200 SC Method 240 SL	3.5 10	14.2 bc	14.3
Escort XP Esplanade200 SC Method 240 SL	0.33 3.5 10	11.6 ab	14.8
Embark 2S Escort XP Method 240 SL	6 0.2 10	11.8 ab	14.7
			n.s.

Table 6: Percent seedhead suppression in the tall fescue stand at Port Matilda. This experiment was visually rated for tall fescue seedhead suppression on June 20 and July 20, 2017 (6 and 10 weeks after treatment, WAT). Treatments were applied on May 9, 2017. All treatments included 0.25% v/v non-ionic surfactant. Seedhead suppression was not rated for control plots. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Rate oz/ac	Percent Tall Fescue Seedhead Suppression	
		6 WAT	10 WAT
Untreated	--	-	-
Segment Method 240 SL	8 10	79 b	79 b
Segment Method 240 SL	14 10	100 c	95 c
Segment Method 240 SL	12 10	97 c	97 c
Plateau Method 240 SL	3 10	98 c	97 c
Plateau Escort XP Method 240 SL	3 0.2 10	100 c	100 c
Plateau Method 240 SL	2 10	96 c	96 c
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	99 c	98 c
Plateau Escort XP Method 240 SL	2 0.2 10	100 c	100 c
Esplanade 200 SC Method 240 SL	3.5 10	0 a	0 a
Escort XP Esplanade 200 SC Method 240 SL	0.33 3.5 10	96 c	98 c
Embark 2S Escort XP Method 240 SL	6 0.2 10	99 c	99 c
Seedhead suppression was not rated for control plots.			

Table 7: Percent turf grass cover at Port Matilda. The treatments were visually evaluated for turf cover on May 8 and July 28, 2017 (0 and 11 weeks after treatment, WAT). The percent change in turf cover is the difference between 11 WAT ratings and 0 WAT ratings. Treatments were applied May 9, 2017. All treatments included 0.25% v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Rate oz/ac	Percent Turf Cover		Change in Turf Cover
		0 WAT	11 WAT	11 WAT
Untreated	--	54	63 b	9
Segment Method 240 SL	8 10	53	46 a	-7
Segment Method 240 SL	14 10	55	52 ab	-3
Segment Method 240 SL	12 10	51	48 ab	-3
Plateau Method 240 SL	3 10	51	50 ab	-1
Plateau Escort XP Method 240 SL	3 0.2 10	53	51 ab	-1
Plateau Method 240 SL	2 10	51	49 ab	-2
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	53	44 a	-9
Plateau Escort XP Method 240 SL	2 0.2 10	54	54 ab	0
Esplanade 200 SC Method 240 SL	3.5 10	50	45 a	-5
Escort XP Esplanade 200 SC Method 240 SL	33 3.5 10	51	48 ab	-3
Embark 2S Escort XP Method 240 SL	6 0.2 10	50	48 ab	-2

Table 8: Phytotoxicity of the turf grass stand at Port Matilda. The experiment was visually evaluated for turf grass phytotoxicity using a scale of 0-10 where "0" = healthy, green; "5" = moderate discoloration; "10" = completely necrotic, brown. This experiment visually rated on June 6 and July 20, 2017 (4 and 10 weeks after treatment, WAT). Treatments were applied on May 9, 2017. All treatments included 0.25% v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Rate oz/ac	Turf grass Phytotoxicity (0-10) Scale	
		4 WAT	10 WAT
Untreated	--	0 a	0
Segment Method 240 SL	8 10	0.8 ab	1
Segment Method 240 SL	14 10	3.3 d	1
Segment Method 240 SL	12 10	2.3 bcd	0.5
Plateau Method 240 SL	3 10	2.3 bcd	0.8
Plateau Escort XP Method 240 SL	3 0.2 10	1.8 abcd	0.5
Plateau Method 240 SL	2 10	1.3 abc	1
Plateau Esplanade 200 SC Method 240 SL	2 3.5 10	1.8 abcd	0.5
Plateau Escort XP Method 240 SL	2 0.2 10	2.5 bcd	0.8
Esplanade 200 SC Method 240 SL	3.5 10	0 a	1
Escort XP Esplanade 200 SC Method 240 SL	0.33 3.5 10	1.5 abcd	0.8
Embark 2S Escort XP Method 240 SL	6 0.2 10	3 cd	1
			n.s.

EVALUATION OF SEED MIXES AND SEEDING METHODS FOR OVERSEEDING LOW GROWING TURF GROUNDCOVER AROUND CABLE GUIDERAILS

Herbicide trade and common names: Triplet L.O.: 2,4-D + Mecoprop-p + Dicamba

Plant common and scientific names: annual ryegrass *(Lolium multiflorum,* LOLMU*)*, creeping red fescue *(Festuca rubra L.,* FESRU*)*, hard fescue *(Festuca brevipila,* FESBR*)*, sheep fescue *(Festuca ovina L.,* FESOV*)*

Seed Mixes: Formula L: 35% creeping red fescue, 55% hard fescue, 10% annual ryegrass
Modified Formula L: 35% creeping red fescue, 55% sheep fescue, 10% annual ryegrass
Sheep fescue: 100% sheep fescue

ABSTRACT

Vegetation management under cable guiderails is challenging because mowing around these structures may require high levels of labor or specialized equipment, while the traditional approach of applying herbicides to create bareground under the traditional shoulder guiderails often leads to erosion when applied to this newer cable guiderail system in turf within the median. One possible solution is to convert the vegetation under the cable guiderails to low growing turf to reduce mowing cycles. Creeping red fescue and hard fescue, found in PennDOT formula L are reliable, low maintenance turf species. Sheep fescue has shown promise as a low growing groundcover in previous research[10]. The goal of this study was to test three seed mixes and three seeding methods for successful establishment of low maintenance turf near cable guiderails. The seed mixes tested included PennDOT Formula L, modified Formula L (hard fescue replaced with sheep fescue), and sheep fescue alone. The seeding methods included broadcast seeding, slice seeding with a slice seeder attached to a tractor and soil preparation with a disc harrow attached to a tractor followed by broadcast seeding. At the end of the first growing season, modified Formula L was the most successful seed mix and disc/ broadcast was the most successful seeding method.

INTRODUCTION

Cable guiderails are being constructed in the medians of limited access roadways across Pennsylvania as a means of preventing vehicles from crossing into the path of oncoming traffic. Vegetation management under cable guiderails is challenging because the traditional approach of creating and maintaining bareground under the shoulder guiderail is often not suitable for these structures. The placement of the cable guiderails in the median is often on sloped and easily erodible ground, so disturbing the vegetation can result in severe loss of soil. Mowing under the rail requires specialized equipment or large amounts of labor. One possible solution is to convert the vegetation under the guiderails to a low growing competitive turf species such as creeping red fescue and hard fescue found in PennDOT Formula L. Sheep fescue, another low growing grass species, has shown promise as a competitive ground cover in previous research.

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[10] Johnson, J. M. et al 2016. Comparing Spring Seeded Formula L Seed Mix at Two Rates and Sheep Fescue for Groundcover Establishment in a Roadside Application – First Year Results. Roadside Vegetation Management Research – 2016 Report. pp 42-44.

To avoid the potential for soil erosion while the new turf is being established, seed was applied as an overseeding process to existing turf. The purpose of this experiment was to test seeding methods and seed mixes for potential to establish under cable guiderail in the presence of existing turf cover. This paper presents first year results following spring seeding.

MATERIALS AND METHODS

The experiment was conducted at two sites in central Pennsylvania in 2017. One is about one mile north of State College, in the median of I-99 near the Shiloh Road exit (hereafter called Shiloh Road). The second site, also in the median of I-99 is located about 12 miles south of State College near the Port Matilda exit (hereafter called Port Matilda). Both sites had cable guiderails in the median that had been installed for three or more years. The three seeding methods tested were broadcast seeding with no soil preparation, overseeding with an Olathe model 93 slice seeder attached to a Kubota 2500 tractor, and soil preparation with a disc harrow attached to a Kubota 2500 tractor followed by broadcast seeding. Three seed mixes were also tested: PennDOT Formula L, modified Formula L (sheep fescue replaced the hard fescue component), and sheep fescue alone. The Shiloh Road and Port Matilda sites were seeded the week of April 17, and April 24, respectively. Formula L and modified Formula L were seeded at 48 lb per 1000 sy, Sheep fescue was seeded at 54 lb per 1000 sq yd. Complete fertilizer was applied to all plots according to soil test recommendations at 1 lb Nitrogen per 1000 sq. ft. Fall ratings were conducted on September 21 and September 28 for Port Matilda and Shiloh Road, respectively. Triplet L.O. was applied at 2 quarts per acre on July 25 and July 27 at the Shiloh Road and Port Matilda sites, respectively. Plots at Port Matilda were 12 by 42 feet while plots at Shiloh Road were 12 by 20 feet. Ratings were performed using a sampling method. At Port Matilda, each plot was visually rated using four fixed sub-plots, one square meter in size, while at Shiloh Road, three, one square meter fixed sub-plots were rated. All data were subject to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$) treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

The Interaction between seed mix and seeding method was not statistically significant. In other words, the effect of the type of seed mix used did not depend on the seeding method and correspondingly, the effect of the seeding method did not depend on the seed mix used. The main effects are described as follows. At the Shiloh Road site, disc / broadcast seeding produced the best results with a 11.3% increase in fine fescue turf cover followed by slice seeder (8.4%), and broadcast (5.6%) (Table 1). Modified Formula L produced the largest increase in fine fescue cover (12.8%), followed by Formula L (6.4%), and sheep fescue (6%) (Table 2).

At the Port Matilda site, the disc/ broadcast seeding method produced the largest increase (18.2%) in fine fescue turf cover, followed by broadcast seeding (8.1%), and slice seeding (6.4%) (Table 3). An anomaly showing that the turf cover in the untreated check plots increased slightly more than the disc/broadcast seeded plots was likely due to inaccuracy in measurement of turf cover. Also at the Port Matilda site, modified Formula L seed mix produced the largest increase in fine fescue cover (12.7%), followed by Formula L (10.3%), and sheep fescue (9.6%)

(Table 4). Sheep fescue is reported to perform better in seed mixes than when used alone[11]. This may help explain why plots seeded to modified Formula L had the largest increase in fine fescue cover at both sites (12.8 and 12.7 percent), but plots seeded to sheep fescue alone had the smallest increase (6 and 9.6 percent).

Soil preparation with a disc harrow followed by broadcast seeding proved to be the most effective seeding method of the three methods tested in this experiment. The disc harrow opened up cuts in the sod so that seed could come in contact with bare soil. Slice seeding is designed to achieve the same goal with less soil disturbance as it deposits seed in the slits created as the machine moves forward. The slice seeder may have been set to cut and deposit seed too deeply for optimum germination. Recommendations suggest seeding sheep fescue to a depth of ¼ inch or less and hard fescue to a depth of ½ inch or less and advise that sheep fescue seedlings may be difficult to find until the second year of establishment.[12] Broadcast seeding requires little or no special equipment. The biggest drawback to broadcast seeding into an existing turf cover is getting the seed in contact with the soil. Mowing prior to seeding to reduce the amount of leaf tissue present and using a leaf blower to remove clippings can help expose soil and encourage seed germination. Pulling a cultipacker or roller over the site after seeding can aid in germination and establishment by pressing the seed into the soil.

Conditions and soils at the two sites were quite different. The Port Matilda site was much more exposed to wind and weather and had coarse textured soil that appeared to have originated from shale which was visible on a nearby embankment. Shiloh Road, on the other hand was situated on a median with a drainage swale down the middle and was protected from wind because much of the median was below the level of the roadway. Soil was heavier and drained more slowly than that of the Port Matilda site. Even with these differences, overall, across three seed types and all seeding methods, there was no significant difference between the two sites in terms of increase in fine fescue cover at season end, with Port Matilda and Shiloh Road showing increases of 10.5 and 9.0 percent, respectively.

CONCLUSIONS

After the first season, modified Formula L has demonstrated the best establishment of the seed mixes tested. Ongoing ratings will be conducted to see how the seed mixes develop over the long term. This experiment represents the first step and first year in defining a suitable planting method for use under median cable guiderails where overseeding fine fescue into a tall fescue bluegrass mix has been attempted. This is also a chance to look at low maintenance fine fescue seed types for providing the best establishment, cover, maintenance quality and aesthetic value for the roadside. A second seeding trial has been planned and established at new locations to better define seeding methods.

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[11] http://www.roads.maryland.gov/OPR_Research/MD-16-SHA-UMCES-6-3_Turfgrass_Report.pdf

[12] USDA Natural Resource Conservation Service Plant Guide. http://www.wwccd.net/wp-content/uploads/2015/08/Sheep-Fescue.pdf

MANAGEMENT IMPLICATIONS

The modified Formula L and the standard Formula L both performed well enough to be considered for use as a low growing groundcover under cable guiderails. However, further ratings are necessary to determine the best establishment method. Cutting the sod with a disc harrow followed by broadcast seeding was the best method for seeding into existing turf tested in this experiment. The importance of some type of soil preparation cannot be overstated. Seed soil contact is essential for successful germination and establishment of any type of turfgrass.

Table 1. Turf cover based on seeding method for the Shiloh Road site. Plots were visually rated for cover. The initial rating was done on April 12 and the fall rating was conducted on September 28. Seeding occurred the week of April 17. Each value is the mean of 4 replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$

Seeding Method	Percent Total Turf Cover 4/12/17	Percent Fine Fescue Cover 4/12/17	Percent Fine Fescue Cover 9/28/17	Change in Cover 2017 Growing Season
Broadcast	53.2 a	18.1 a	23.7 a	5.6
Slice Seeder	58.1 a	23.1 a	31.5 a	8.4
Disc/Broadcast	60.4 a	21.4 a	32.7 a	11.3
Unseeded Check	75 b	40 b	57.7 b	17.7
				n.s.

Table 2. Turf cover based on seed mix for the Shiloh Road site. Plots were visually rated for cover. The initial rating was done on April 12 and the fall rating was conducted on September 28. Seeding occurred the week of April 17. Each value is the mean of 4 replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Seed Type	Percent Total Turf Cover 4/12/17	Percent Fine Fescue Cover 4/12/17	Percent Fine Fescue Cover 9/28/17	Change in Cover 2017 Growing Season
Formula L	60.3 a	22.7 a	29.1 a	6.4
Modified Formula L	53.6 a	17 a	29.8 a	12.8
Sheep Fescue	57.8 a	23.1 a	29.1 a	6.0
				n.s.

Table 3. Turf cover based on seeding method for the Port Matilda site. Plots were visually rated for cover. The initial rating was done on April 24 and the fall rating was conducted on September 21. Seeding occurred the week of April 24. Each value is the mean of 4 replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$

Seeding Method	Percent Total Turf Cover 4/24/17	Percent Fine Fescue Cover 4/24/17	Percent Fine Fescue Cover 9/21/17	Change in Cover 2017 Growing Season
Broadcast	38.8 ab	16.4 a	24.4 ab	8.1 a
Slice Seeder	34.3 a	15.9 a	22.2 a	6.4 a
Disc/Broadcast	46.1 b	32.9 b	51.1 c	18.2 b
Unseeded Check	34.1 a	23 ab	42.6 bc	19.6 b

Table 4. Turf cover based on seed mix for the Port Matilda site. Plots were visually rated for cover. The initial rating was done on April 24 and the fall rating was conducted on September 21. Seeding occurred the week of April 24. Each value is the mean of 4 replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$

Seed Type	Percent Total Turf Cover 4/24/17	Percent Fine Fescue Cover 4/24/17	Percent Fine Fescue Cover 9/21/17	Change in Cover 2017 Growing Season
Formula L	36.1	23.4	33.8	10.3
Modified Formula L	39.9	17.5	30.2	12.7
Sheep fescue	43.1	24.2	33.8	9.6
	n.s.	n.s.	n.s.	n.s.

COMPARISON OF ESPLANADE, RIMSULFURON, AND ESPLANADE PLUS RIMSULFURON TO SOME COMMONLY USED TANK MIXES FOR SEASON LONG WEED CONTROL

Herbicide trade and common names: Round Up Pro *(glyphosate)*, Esplanade 200 SC *(indaziflam)*, Rezilon *(rimsulfuron)*, IAF-RIS *(indaziflam + rimsulfuron)*, Oust XP *(sulfometron)*, Portfolio 4F *(sulfentrazone)*, Cleantraxx *(penoxsulam + oxyfluorfen)*, and Plateau *(imazapic)*

Plant common and scientific names: barnyard grass (*Echinochloa crusgalli,* ECHCR), prostrate spurge, *(Euphorbia humistrata,* EUPHU*)*, common ragweed *(Ambrosia artemisiifolia,* AMBEL*)*, buckhorn plantain *(Plantago lanceolate,* PLALA*)*, prostrate knotweed *(Polygonum aviculare,* POLAV*)*, and Pennsylvania knotweed (*Polygonum pennsylvanicum,* POLPE) and heath aster (*Aster pilosus,* ASTPI)

ABSTRACT

Safety, aesthetics, and maintenance activities require that the area around signposts, reflectors, and other hard structures be maintained free of vegetation. In this experiment, various herbicide combinations were partnered with Round Up Pro to determine if the combinations would offer season long weed control. Treatments included Round Up Pro alone at 64 oz/ac, Esplanade at 3.5, 5, or 7 oz/ac plus Round Up Pro at 64 oz/ac, Rezilon[13] at 3 oz/ac plus Round Up Pro at 64 oz/ac, IAF-RIS at 3, 4.5, or 6 oz/ac plus Round Up Pro at 64 oz/ac, Esplanade at 3.5 oz/ac plus Oust XP at 2 oz/ac and Round Up Pro at 64 oz/ac, CleanTraxx at 64 oz/ac plus Round Up Pro at 64 oz/ac, CleanTraxx at 64 oz/ac plus Oust XP at 2 oz/ac and Round Up Pro at 64 oz/ac, Portfolio 4F at 12 oz/ac plus Round Up Pro at 64 oz/ac, and Plateau at 12 oz/ac plus Round Up Pro at 64 oz/ac.[14] All tank mixes resulted in greater than 95 percent bareground at season end (124 DAT, days after treatment). Roundup Pro alone yielded 82.9 percent bareground at 124 DAT.

INTRODUCTION

Bareground weed control, designed to keep the area under guiderails, sign posts, and other structures free of vegetation is an essential component of the PennnDOT's vegetation management program. The advantages of maintaining these areas free of vegetation include enhanced safety, aesthetics, and improved access for maintenance. To achieve this goal, a tank mix of herbicides designed to eliminate vegetation for a growing season is applied. Three components commonly combined in the tank mix, include post emergence, pre-emergence, and broad spectrum residual herbicides. Consideration used to select herbicides include: safety, cost, availability, label restriction or precautions, mode of action, effective control of vegetation, and length of control. In this experiment, several residual herbicide combinations were partnered with Round Up Pro to determine if the combinations would offer season long bareground control. The tank mix partners included Esplanade, Esplanade-Oust, Rezilon, IAF-RIS, CleanTraxx, CleanTraxx-Oust, Portfolio 4F, and Plateau. Rezilon (*Rimsulforon*) and IAF-RIS

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[13] Rezilon was used as an experimental herbicide for this experiment.

[14] IAF-RIS is an experimental herbicide that may be an alternative once labeled for ROW.

(*Indaziflam + Rimsulfuron*) are not labeled for ROW sites. Rimsulfuron is labeled for use in Pennsylvania. Indaziflam is labeled for ROW use.

MATERIALS AND METHODS

The experimental site was located at the Bald Eagle State Park in the Boat Winter Storage Area near Howard, Pennsylvania. The site was a gravel parking lot.

Treatments included Round Up Pro alone at 64 oz/ac, Esplanade at 3.5, 5, or 7 oz/ac plus Round Up Pro at 64 oz/ac, Rezilon at 3 oz/ac plus Round Up Pro at 64 oz/ac, IAF-RIS at 3, 4.5, or 6 oz/ac plus Round Up Pro at 64 oz/ac, Esplanade at 3.5 oz/ac plus Oust XP at 2 oz/ac and Round Up Pro at 64 oz/ac, CleanTraxx at 64 oz/ac plus Round Up Pro at 64 oz/ac, CleanTraxx at 64 oz/ac plus Oust XP at 2 oz/ac and Round Up Pro at 64 oz/ac, Portfolio 4F at 12 oz/ac plus Round Up Pro at 64 oz/ac, and Plateau at 12 oz/ac plus Round Up Pro at 64 oz/ac. A non-ionic surfactant (i.e. Induce) was added to all herbicide treatments at 0.25% v/v. Treatments were applied at 50 gallons per acre. The experiment was established as a randomized complete block design with four replications. The plots were 10 feet wide by 20 feet long in size. Within each 10' by 20' plot, a 6' strip 20' long was treated while the remaining 4' by 20' strip was used as a non-treated control. The non-treated strips were used as a buffer and to monitor plant species remaining in the plot for comparison with treatment. The most common species present in the control plots during the experiment were barnyard grass (*Echinochloa crusgalli*), prostrate spurge, *(Euphorbia humistrata)*, common ragweed *(Ambrosia artemisiifolia)*, buckhorn plantain *(Plantago lanceolate)*, prostrate knotweed *(Polygonum aviculare)*, Pennsylvania knotweed (*Polygonum pennsylvanicum*) and heath aster (*Aster pilosus*).

The treatments were applied May 24, 2017 using a CO_2 powered back pack sprayer at 37 psi equipped with six-foot boom with four 8006 VS nozzle tips. According to http://www.wunderground.com, rainfall in the area was observed on following days May 25 (0.11 inches), May 28 (0.22 inches), May 29 (0.64 inches), and May 31 (0.15 inches). The total rainfall 7 days after application was 1.12 inches.

The experiment was visually rated for percent bareground cover on May 24, June 22, July 22, August 30, and September 25; 0, 29, 58, 98, and 124 days after treatment (DAT) (Table 1).

RESULTS AND DISCUSSION

At 29 DAT, the bareground ranged from 100 to 97.5 percent for the treatments. The untreated check observed 80 percent bareground 29 DAT. By September 25, 124 DAT, there was no statistical difference between the treatments including the Round Up only treatment. Percent bareground ranged from 100 to 82.1 for the treatments. The untreated check bareground was 55.5%. The Esplanade mixes, IAF-RIS mixes, and CleanTraxx plus Oust plus Round Up provided 99-100% control during the length of the experiment. Esplanade 3.5 oz/ac plus Oust XP 2 oz/ac and Round Up 64 oz/ac most effectively controlled vegetation within the plots. Rezilon at 3 oz/ac plus Round Up at 64 oz/ac and Portfolio 4F plus Round Up and CleanTraxx plus Round Up showed reduced bareground control over time. The least effective treatment was Round Up Pro at 64 oz/ac, which contained no residual herbicide. The Round Up at 64 oz/ac treatment was observed to have weed breakthrough 98 DAT. Caution should be used when using Oust XP, CleanTraxx, and Portfolio 4F due to label restrictions.

CONCLUSIONS

Most treatments provided excellent bareground control through the experiment time period. There was no statistically significant difference between the level of control provided by the residual herbicide treatments at 124 DAT. The Round Up only treatment was observed to have weed breakthrough 98 DAT. This is expected since a residual herbicide was not included in this treatment. Herbicide combinations of Esplanade plus Round Up and IAF-RIS plus Round UP appear to be effective. The addition of Oust XP to the CleanTraxx tank mix and Esplanade tank mix increased control but their addition was not statistically significant. CleanTraxx plus Round Up, Portfolio 4F plus Round Up, and Plateau plus Round Up appear to slightly lose effectiveness over time.

MANAGEMENT IMPLICATIONS

Esplanade at 3.5 oz/ac plus Oust XP at 2 oz/ac and Round Up Pro at 64oz/ac was the most effective treatment during this experiment. Herbicide combinations of Esplanade plus Round Up and IAF-RIS plus Round UP demonstrated excellent bareground control. Further research needs to be conducted determine the best rate of Esplanade when combined with Round Up Pro for bareground control. Results for this experiment showed no difference in control between Esplanade at 3.5 oz/ac and Esplanade at 7 oz/ac. At close to $8.00 per ounce, reducing the rate of Esplanade without sacrificing control is a consideration. Additionally, IAF-RIS should be further tested to determine consistent results as well as identifying the appropriate rate. IAF-RIS is an experimental herbicide that may be an alternative product for bareground weed control. CleanTraxx plus Oust XP and Round Up provided acceptable bareground control. There are labeling cautions and language that may preclude regarding CleanTraxx, Portfolio 4F, and Oust XP. The CleanTraxx label requires a 25-foot buffer area between treated areas and bodies of water.[15] The Portfolio 4F label contains groundwater and surface water advisory statements about potential contamination.[16] The Oust XP label requires a 25-foot buffer area between treated areas and bodies of water.[17]

[15] Dow Agro Sciences LLC. Cleantraxx. Internet April 12, 2018
[16] Wilbur-Ellis Company LLC. Portfolio 4F. Internet April 12, 2018
[17] Bayer CropScience LP. Oust XP. Internet April 12, 2018

Table 1: Percent bareground. The trial was visually rated for percent bareground on May 24, June 22, July 21, August 30, and September 25 (0, 29, 58, 98, 124 DAT). Treatments were applied May 24, 2017. All treatments included a non-ionic surfactant (Induce) at 0.25% 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	Rate oz/ac	Percent Bareground 29 DAT	Percent Bareground 58 DAT	Percent Bareground 98 DAT	Percent Bareground 124 DAT
Untreated	--	80 b	77 b	61.4 b	55.5 b
Round Up Pro	64	98.2 a	93.5 a	78.7 ab	82.9 a
Esplanade Round Up Pro	3.5 64	99.8 a	99.9 a	99.2 a	99.2 a
Esplanade Round Up Pro	5 64	99.8 a	99.9 a	99.8 a	99.8 a
Esplanade Round Up Pro	7 64	99.9 a	99.8 a	99.6 a	99.6 a
Relizon Round Up Pro	3 64	97.5a	98.4 a	94.8 a	95.1 a
IAF-RIS Round Up Pro	3 64	99.7 a	99.8 a	99.7 a	99.4 a
IAF-RIS Round Up Pro	4.5 64	99.8 a	99.7 a	99.7 a	99.6 a
IAF-RIS Round Up Pro	6 64	99.9 a	100 a	99.9 a	99.9 a
Esplanade Oust XP Round Up Pro	3.5 2 64	99.9 a	100 a	100 a	100 a
CleanTraxx Round Up Pro	64 64	99.7 a	99.5 a	98.5 a	98.5 a
CleanTraxx Oust XP Round Up Pro	64 2 64	100 a	100 a	99.9 a	99.6 a
Portfolio 4F Round Up Pro	12 64	99.4 a	98.4 a	97.7 a	95.2 a
Plateau Round Up Pro	12 64	99.4 a	99.8 a	98.5 a	98.3 a