THE COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

ROADSIDE VEGETATION MANAGEMENT
RESEARCH REPORT
SECOND YEAR REPORT

THE PENNSYLVANIA STATE UNIVERSITY
RESEARCH PROJECT # 85-08
REPORT # PA 87-021 + 85-08

PENNSTATE

1855

INTRODUCTION

Members of the Pennsylvania State University's College of Agriculture, in cooperation with the Pennsylvania Department of Transportation have continued a research project to investigate various aspects of roadside vegetation management. The original project was initiated in October of 1985 and continued through March of 1987. The project report describing that research is report number PA 86-013 + 85-08. In addition, a Vegetation Management Manual was produced (Report# PA 86-018 + 85-08). The research project has been sustained throughout 1987 and is described in this report.

The research for the period 3/15/87 - 3/15/88 was identified in three tasks, with each task containing one or more objectives. The first task was to evaluate the effects of Plant Growth Regulators on the growth of roadside turf. Five experiments were conducted and they are discussed in the Plant Growth Regulator Study, which is section one of this report.

The second task contained several objectives to investigate the control of Canada thistle, herbaceous weeds, and brush along the roadside. They are presented in three different sections of this report; the Canada thistle Control Study, Herbaceous Weed Control Study, and the Brush Control Study.

The Canada thistle Control Study consisted of four experiments. The included the evaluation of several herbicides for their efficacy on Canada thistle and to the crownvetch groundcover. Also, an experiment to measure the total nonstructural carbohydrates (energy reserves) of the thistle plant throughout the season was performed.

The Herbaceous Weed Control Study consisted of four herbicide screening trials throughout the state in which several herbicides were applied to determine their efficacy on the control of herbaceous weeds. These trials also measured the effects of the treatments on the existing groundcover; either grass or crownvetch. In addition, an experiment was conducted to establish crownvetch by broadcasting the seed onto a site in which several brush control materials were evaluated

The Brush Control Study evaluated the efficacy of several different applications to control roadside brush. They included a fall foliar experiment, two dormant stem experiments, and three basal bark experiments.

The objective of the third task was to make necessary changes or additions to the Vegetation Management Manual. Slight changes and additions to the manual were made and will appear in subsequent reprints when supplies of the original publications are requested. Major additions or supplements to the manual however, were not necessary.

AKNOWLEDGEMENTS

The research produced was part of a Pennsylvania State University project in cooperation with the Pennsylvania Department of Transportation. Contributors include the following Penn State faculty and staff members.

Thomas L. Watschke	Professor of Turfgrass Science and Project Manager
Nathen L. Hartwig	Professor of Weed Science
Larry J. Kuhns	Associate Professor of Ornamental Horticulture
Gregory T. Lyman	Project Assistant and Coordinator
Stephen J. Olsen	Graduate Student of Weed Science
Mark G. Prinster	Research Technologist

We wish to thank the Penn DOT District Roadside Specialists for their assistance and participation in many phases of this project. We would also like to recognize Mr. Ron Stahl and Ms. Connie Bosserman in the Central Office for their commitment and efforts toward this project.

This project was sponsored by the Pennsylvania Department of Transportation.

TABLE OF CONTENTS

PLANT GROWTH REGULATOR STUDY

The plant growth regulator study for 1987 consisted of five experiments. Several compounds, application timings, and application techniques were evaluated. The first experiment was conducted in district 6 near Philadelphia, to examine the effects of several compounds and some combinations on the growth and development of an unmowed roadside sward of mixed vegetation. Experiment two was conducted in district 9 near Tyrone with the same objectives as experiment one, but with some of the treatments being different. The third experiment was conducted to asses the effects of several compounds and some combinations on the growth of a mowed roadside turf. This experiment was conducted near Philadelphia on a site adjacent to the one used in experiment one. Experiments four and five conducted at two different locations, but were both designed to compare the effects of different nozzle sizes in a Radiarc Nozzle System with a conventional flat fan nozzle/boom system for applying plant growth regulators. Experiment four was conducted near Philadelphia, while experiment five was conducted at the Penn State Horticulture Research Farm in Rock Springs.

All of the products used in this study are listed in Table 1. For ease of reading, the compounds will be referred to as product names when discussed in the text.

Table 1. Listing of various PGR used in the various experiments in 1987.

Product Name	Common Name	Formulation	Manufacturer
Embark	Mefluidide	2 S	PBI Gordon Inc.
Ferromec	Liquid Iron	- -	PBI Gordon Inc.
XE-1019	Uniconizole	- -	Chevron Co.
Cutless	Flurprimidol	10 W	Elanco Division, Eli Lilly Co.
Manage	Mon-8000	75 WP	Monsanto Co.
Oust	Sulfometuron methyl	75 DG	E.I. Dupont De Nemours Inc.
Escort	Metsulfuron methyl	60 DG	E.I. Dupont De Nemours Inc.
Telar	Chlorsulfuron	75 DG	E.I. Dupont De Nemours Inc.
Trooper	Dicamba	4#/Gallon	Monsanto Co.
ACP-1911X	Experimental	Experimental	American Cyanamid
HOE-704	Experimental	Experimental	Hoechst-Roussel Agri-Vet Co.
MON-4625	Experimental	Experimental	Monsanto Co.

Experiment 1

Objective

To asses the effects of several experimental and commercial plant growth regulating compounds, and some combinations thereof on the growth and development of unmowed roadside vegetation (mostly grasses).

Materials and Methods

Chemical treatments were applied to an unmowed stand of predominantly tall fescue (Festuca arundinacea Schreb.) on April 21, 1987 (Table 2). The site was approximately 20 years old and was located near Philadelphia. The tall fescue had been mowed at least once every year (the median section was vegetated with crownvetch). Plots were 10' x 30' and were replicated three times in a randomized complete block design. All treatments were applied with flat fan nozzles mounted on a boom in 40 gallons of water per acre with 0.25% v/v non-ionic surfactant. Rates will be referred to in ounces of product per acre in all data tables.

Table 2. Materials and rates of application for Experiment 1.

Treatment	Ounces Product/A	Pounds AI/ Acre
Embark	24.0	0.38
Embark +	24.0 +	0.38
Ferromec	96.0	-.--
Embark +	9.7 +	0.15
XE-1019	4.8	0.15
Embark +	8.0 +	0.13
Cutless	24.0	0.75
Embark +	9.6	0.15
Escort	0.125 +	0.005
Manage	4.0	0.19
Manage +	4.0 +	0.19
Oust	0.125	0.006
Manage +	4.0 +	0.19
Telar	0.25	0.12
Manage +	4.0 +	0.19
Escort	0.33	0.13
Manage +	4.0 +	0.19
Telar+	0.25 +	0.12
Trooper	16.0	0.05
Escort	0.33	0.013
Escort +	0.125 +	0.005
Telar	0.25	0.12
ACP-1911X	4.0	0.45
ACP-1911X	6.0	0.62
ACP-1911X	8.0	0.9
Check	0.00	0.00

The treatments were evaluated several times during the season. The individual rating periods are referred to in the following tables in number of weeks after treatment (WAT). At two and four weeks after treatment, injury or phytotoxic response due to treatment was evaluated. During the first month following treatment, reduced vegetation quality is most often associated with chemical injury. As the season progresses however, many other factors influence the quality of the treatment.

At six, ten, and twelve weeks after treatment, each individual plot was evaluated on an overall "appearance" basis. The appearance ratings were determined by several factors, including tall fescue seedheads, broadleaf weed, or annual grass invasion. These factors must be included in the rating system to provide more descriptive accounting of the strengths or weaknesses of a particular treatment. The rating scale used was a 0-9 scale with (0) representing dead grass, and (9) representing excellent stand quality. Any rating less than (6) is considered unacceptable for roadside vegetation.

As additional ratings, at ten WAT broadleaf weed invasion was estimated for each plot and 25 WAT, annual grass invasion was estimated.

Results and Discussion

At two weeks after application, all treatments containing Manage, and the Escort combinations with Embark caused unacceptable injury to tall fescue (Table 3). By the fourth week, all treatments containing Manage continued to cause unacceptable injury, while all treatments containing Escort and all rates of ACP-1911X joined the list.

Six WAT, Embark combined with XE-1019 and Cutless was rated below six due to injury associated with the combining chemical rather than the Embark. Grass treated with Manage alone had recovered from initial injury and was rated as acceptable while combinations of Manage with Telar, Oust, and Escort were still unacceptable. All rates of ACP-1911X were rated as acceptable as was Escort alone and in combination with Telar.

Ten WAT, turf treated with Embark alone and in combination with Ferromec, XE-1019, and Cutless had some degree of broadleaf weed encroachment which resulted in ratings that were borderline for acceptance. Swards treated with Manage alone were rated unacceptable due to the presence of broadleaf weeds and a significant amount of seedheads. All other treatments provided adequate seedhead inhibition with the exception of Embark + XE-1019 which only shortened seedheads. Manage applied in combination with Escort, Oust and Telar, and Escort alone and in combination with Embark provided adequate broadleaf weed control but caused substantial injury to tall fescue. These areas were subsequently invaded by yellow foxtail [Setaria lutescens (Weigel.) Hubb.] which masked the injured tall fescue and resulted in appearance ratings that reflect acceptable quality. Manage + Telar + dicamba provided desirable control of broadleaf weeds but failed to consistently suppress the foliar and reproductive growth of tall fescue. All rates of ACP-1911x allowed a significant invasion of broadleaf species, particularly crownvetch (Coronilla varia L.).

Table 3. The effect of several PGR treatments on the injury and appearance of roadside tall fescue.

Treatment	Ounces Product/A	PHYTOTOXICITY RATING [1/] 2 WAT	4 WAT	APPEARANCE RATING [2/] 6 WAT	10 WAT	12 WAT
Embark	24.0	6.7 bcd[3/]	6.3 b	6.0 cd	5.7 abc	6.2 bcd
Embark+Ferromec cdef	24.0+96.0	7.3 ab	6.0 bc	6.3 bcd	5.7 abc	5.5
Embark+XE-1019	9.7+0.17 ai/a	6.7 ab	6.0 bc	5.3 d	6.0 abc	7.2 a
Embark+Cutless ab	0.014+0.84	7.0 bc	6.7 b	5.0 de	5.7 abc	6.5
Embark + Escort bcde	9.7 + 0.125	5.0 g	3.3 e	5.8 cd	7.3 ab	5.8
Manage	4.0	5.5 efg	4.7 d	7.7 ab	4.7 c	4.7 f
Manage+Oust	4.0+0.125	3.7 h	2.3 e	3.7 e	6.0 abc	5.0 ef
Manage+Telar	4.0+0.25	3.7 h	3.0 e	6.3 bcd	7.7 a	5.3 def
Manage+Escort	4.0+0.33	3.0 h	2.3 e	5.0 de	7.0 ab	5.2 ef
Manage+Telar+Trooper	4.0+0.25 +16.0	5.3 fg	6.0 bc	8.0 a	4.7 c	5.5 cdef
Escort cdef	0.33	6.3 cde	4.7 d	6.3 bcd	6.0 abc	5.5
Escort+Telar	0.125+0.25	6.0 def	5.7 bcd	7.0 abc	5.3 bc	5.3 def
ACP-1911X	4.0	7.0 bc	5.7 bcd	7.0 abc	4.3 cd	6.3 abc
ACP-1911X	6.0	6.0 def	5.7 bcd	7.0 abc	4.7 c	6.3 abc
ACP-1911X	8.0	6.7 bcd	5.0 cd	6.0 cd	5.3 bc	6.2 bcd
Check	0.00	8.0 a	8.0 a	8.0 a	2.7 d	2.7 g

1/ - Ratings based on a scale of 0 to 9 : 0 = Dead grass, 9 = No Injury, <6 = Unacceptable for roadside turf

2/ - Ratings based on a scale of 0 to 9 : 0 = dead grass or undesirable vegetative cover, 9 = excellent sward quality, <6 = unacceptable for roadsides.

3/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

The extremely low rating for the check is the result of tall fescue seedhead production, broadleaf weeds, and encroachment by summer annual grasses (foxtail primarily). The appearance ratings for 12 WAT are shown in both Table 3 and 4. Table 4 is provided as more detailed explanation for the numerical appearance ratings. For example, a rating of 5.5 for Escort alone was the result of annual grass encroachment and some lack of seedhead suppression of the tall fescue. A rating of 4.7 for Manage alone is readily justified. The addition of XE-1019 to Embark helped reduce annual grass invasion, and had Trooper been added to control broadleaf invasion, the rating (7.2) would have been even higher. Obviously, the most desirable treatment would be one that suppresses tall fescue seedheads, does not cause injury to tall fescue, and controls broadleaf weed and annual grass invasion. Currently, the only way to provide all of these desired responses is to apply a combination fo products. Future research on this project will be directed, impart, to evaluating such combinations.

Table 4. Listing of the components used in assigning a numerical appearance rating at 12 WAT.

	Ounces Product/ACRE	Broadleaf Weeds	Annual Grasses	Tall Fescue Seedheads	Appearance[1/] Rating
Embark	24.0	x x x[2/]	x x	x	6.2 bcd[3/]
Embark + Ferromec	24.0 + 96.0	x x x	x x x		5.5 cdef
Embark + XE-1019	9.6 +0.15 ai/A	x x x			7.2 a
Embark + Cutless	8.0 + 24.0	x x x		x x x	6.5 ab
Embark + Escort	9.6 + 0.125		x x x		5.8 bcde
Manage	4.0	x x x	x x x	x x x	4.7 f
Manage + Oust	4.0 + 0.125	x x	x x x		5.0 ef
Manage + Telar	4.0 + 0.25		x x x		5.3 def
Manage + Escort	4.0 + 0.33	x x	x x x		5.2 ef
Manage +Telar + Trooper	4.0 +0.25 +16.0		x x	x x	5.5 cdef
Escort	0.33	x x x	x x x	x x	5.5 cdef
Escort + Telar	0.125 + 0.25		x x x		5.3 def
ACP-1911X	4.0	x x x			6.3 abc
ACP-1911X	6.0	x x x			6.3 abc
ACP-1911X	8.0	x x x			6.2 bcd
Check	0.00	x x x	x x x	x x x	2.7 g

1/ - Ratings based on a scale of 0 to 9 : 0 = dead grass or undesirable vegetative cover, 9 = excellent sward quality, <6 = unacceptable for roadsides.

2/ - An (X) indicates the presence of a particular item listing in a replication (three X's indicates presence in all three replications

3/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

The ratings in Table 5 are provided to clarify the appearance of the treated areas 25 WAT with respect to annual grasses and, in the case of ACP-1911X particularly, conversion of the roadside vegetation from predominantly grass to crownvetch. Those treatments containing Oust, Telar, and/or Escort all caused the roadside vegetation to be composed of more than 80% foxtail. The successful foxtail invasion was the result of significant injury and prolonged suppression of the tall fescue during the time when foxtail was germinating and developing. A certain base level of invasion is natural (the check had 32%) and occurs every year, however, converting the stand to predominantly annual grass for most of the season could potentially lead to significant stand reduction of tall fescue and could result in decreased stabilization of the roadbed.

Table 5. Conversion of vegetation due to PGR use.

Treatment	Ounces Product /Acre	Non-Grass species 12 WAT	Annual grasses 25 WAT
		- - - - - - - %	- - - - - - -
Embark	24.0	45.0 bcd	36.7 de [1/]
Embark + Ferromec	24.0 + 96.0	60.0 abc	33.3 de
Embark + XE-1019	9.7 + .15 ai/A	70.0 abc	75.0 abc
Embark + Cutless	8.0 + 24.0	65.0 abc	26.7 de
Embark + Escort	9.7 + 0.125	8.3 e	97.0 a
Manage	4.0	61.7 abc	58.3 abcd
Manage + Oust	4.0+ 0.125	40.0 cde	86.7 ab
Manage + Telar	4.0 + 0.25	11.7 e	96.7 a
Manage + Escort	4.0 + 0.33	6.0 e	96.3 a
Manage + Telar+ Trooper	4.0 + 0.25 + 16.0	6.0 e	91.7 a
Escort	0.33	16.0 de	83.3 ab
Escort + Telar	0.125 + 0.25	8.3 e	96.0 a
ACP-1911X	4.0	81.7 a	11.7 e
ACP-1911X	6.0	78.3 ab	43.3 cde
ACP-1911X	8.0	75.0 ab	50.0 bcde
Check	0.00	93.3 a	32.0 de

1/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

Experiment 2

Objective

To assess the effects of several compounds and combinations thereof on the growth and development of an unmowed roadside turf.

Materials and Methods

The treatments were applied on May 1, 1987 to a tall fescue roadside near Tyrone Pa. The treated plots were 10 by 50 ft and were replicated three times in a randomized complete block design. All treatments were applied in 30 gallons of water per acre and contained 0.25% non-ionic surfactant. The application equipment utilized in experiment one was also used for this application. The treatments are listed in Table 6 and the rate is expressed in ounces of product per acre and pounds of active ingredient per acre. As in experiment one, subsequent tables will express the rates as ounces of product per acre.

Table 6. Materials and rates of application for Experiment 2.

Treatment	Ounces Product/Acre	Pounds Active Ingredient/Acre
Embark	24.0	0.38
Embark +	24.0	0.38
Ferromec	96.0	-.--
Embark +	9.6	0.15
XE-1019	4.8	0.15
Embark +	9.6	0.15
XE-1019	8.0	0.25
Embark +	8.0	0.12
Cutless	24.0	0.75
Embark +	9.6	0.15
Escort	0.20	0.008
Escort	0.25	0.010
Manage +	4.0	0.19
Telar	0.25	0.12
Roundup +	4.0	0.13
Telar	0.25	0.12
ACP-1911x	6.0	0.62
HOE-704	33.7	-.--
HOE-704	50.5	-.--
HOE-704	68.2	-.--
HOE-704 +	33.7	-.--
Telar	0.25	0.12
HOE-704 +	33.7	-.--
Escort	0.125	0.005
HOE-704 +	33.7	-.--
Embark	8.0	0.12
MON-4625	64.0	-.--
Check	0.00	0.00

The treatments were rated at two, four, and eleven weeks after treatment (WAT). At two and four WAT, the phytotoxic response of the tall fescue was rated using the same scale used in experiment one. At eleven weeks after treatment, the plots were rated on an appearance basis. The appearance rating was similar to those used in experiment one except that the factors involved in developing the appearance rating were slightly different. For this experiment, stand density, tall fescue seedhead emergence, and broadleaf weed invasion were the criteria used in determining plot appearance. Invasion by annual grasses did not occur on this site. The percentage of broadleaf weeds and the percentage of tall fescue seedheads present in each plot was also determined at eleven WAT.

Results and Discussion

At two weeks after application, HOE-704 at 0.66 and 0.89 lbs ai/A, Embark + Escort, and Hoe-704 + Escort caused unacceptable injury to tall fescue (Table 7). All other treatments caused some injury when compared to the check but the injury was considered to be tolerable for roadsides. Embark + Ferromec tended to improve the foliar quality of the grass at this time by enhancing the green color of foliage.

By four weeks after application, all combination treatments that included sulfonyl urea products (Escort, Telar) caused unacceptable injury to tall fescue. The foliar quality of grass treated with HOE-704 at 0.66 lbs. ai/A had improved by this time and was considered acceptable, whereas HOE-704 at 0.89 lbs. ai/A was still causing unacceptable phytotoxicity. Improved foliar color caused by Embark + Ferromec at two weeks was short-lived and quality appeared similar to the check at this time.

Table 7. Effect of PGR applied to a tall fescue roadside sward.

TREATMENT	OUNCES PRODUCT/A	Phytotoxicity Rating[1/] 2 WAT	4 WAT	Appearance[2/] 11 WAT
Embark	24.0	7.3 bcd[3/]	7.3 ab	5.3 abcde
Embark + Ferromec	24.0 + 96.0	8.5 a	8.0 a	4.0 de
Embark + XE-1019	9.6 + 4.8	7.7 abc	7.0 abc	6.7 abc
Embark + XE-1019	9.6 + 8.0	7.0 bcde	7.3 ab	5.3 abcde
Embark + Cutless	8.0 + 24.0	6.7 cdef	7.3 ab	5.3 abcde
Embark + Escort	9.6 + 0.20	5.3 gh	4.0 ef	5.3 abcde
Escort	0.25	7.0 bcde	6.0 cd	7.3 ab
Manage + Telar	4.0 + 0.25	6.3 defg	4.7 e	7.7 a
Roundup + Telar	4.0 + 0.25	7.3 bcd	5.7 d	7.7 a
ACP-1911x	6.0	7.3 bcd	6.0 cd	7.7 a
HOE-704	33.7	7.0 bcde	7.3 ab	5.0 bcde
HOE-704	50.5	5.0 hi	6.0 cd	5.7 abcde
HOE-704	68.2	4.3 i	3.3 f	5.0 bcde
HOE-704 + Telar	33.7 + 0.25	6.0 efgh	4.3 ef	6.7 abc
HOE-704 + Escort	33.7 + 0.125	5.7 fgh	4.3 ef	6.3 abcd
HOE-704 + Embark	33.7 + 8.0	6.0 efgh	6.3 bcd	4.3 cde
MON-4625	64.0	6.7 cdef	7.0 abc	6.3 abcd
Check	0.00	8.0 ab	8.0 a	3.7 e

1/ - Ratings based on a scale of 0 to 9 : 0 = Dead grass, 9 = No Injury, <6 = Unacceptable for roadside turf

2/ - Ratings based on a scale of 0 to 9 : 0 = dead grass or undesirable vegetative cover, 9 = excellent sward quality, <6 = unacceptable for roadsides.

3/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

At eleven weeks after application, overall appearance was evaluated in order to better assess the factors causing decline in sward quality (Table 8). Seedhead escapes, broadleaf weed invasion, and inconsistent grass suppression were factors considered in this evaluation. Annual grass invasion was not a factor in this site when compared to the severe annual grass pressure experienced at the Philadelphia site of experiment one. The Tyrone site was located predominantly in a previously wooded section of the route 220 bypass. Therefore, the potential for foxtail seed to be present in the soils used during construction was fairly low. Very few annual grassed of any type were observed at this location. Embark alone and in combination with Ferromec did not provide an acceptable sward appearance due to seedhead emergence and invading broadleaf weeds. The application timing may have been late for good seedhead suppression. Embark applied in combination with the low rate of XE-1019 provided little seedhead suppression but did suppress broadleaves and shortened seedheads thus creating a more acceptable sward appearance. Embark applied in combination with Cutless and the higher rate XE-1019 suppressed seedhead height but also caused tip die-back of the tall fescue and were considered unacceptable. Manage + Telar, Manage + Telar, ACP-1911x, Escort, HOE-704 + Telar and Mon-4625 provided substantial seedhead inhibition and were rated as providing an acceptable sward appearance. Embark + Escort, H0E-

704 + Embark and all rates of HOE-704 alone were considered unacceptable due to prolonged stand injury and inconsistent sward suppression.

Table 8. Listing of components used in assigning a numerical appearance rating 11 WAT.

TREATMENT	PRODUCT/A	Tall Fescue Seedheads	Broadleaf Weeds	Appearance[1/]
Embark	24.0	x x x[2/]	x	5.3 abcde[3/]
Embark + Ferromec	24.0 + 96.0	x x x	x x	4.0 de
Embark + XE-1019	9.6 + 4.8	x x x		6.7 abc
Embark + XE-1019	9.6 + 8.0	x x x		5.3 abcde
Embark + Cutless	8.0 + 24.0	x x x	x x	5.3 abcde
Embark + Escort	9.6 + 0.20			5.3 abcde
Escort	0.25	x		7.3 ab
Manage + Telar	4.0 + 0.25			7.7 a
Roundup + Telar	4.0 + 0.25			7.7 a
ACP-1911x	6.0		x x	7.7 a
HOE-704	33.7	x x x	x	5.0 bcde
HOE-704	50.5	x x	x x	5.7 abcde
HOE-704	68.2		x x	5.0 bcde
HOE-704 + Telar	33.7 +0.25	x		6.7 abc
HOE-704 + Escort	33.7 + 0.125			6.3 abcd
HOE-704 + Embark	33.7 + 8.0	x x	x	4.3 cde
MON-4625	64.0		x x x	6.3 abcd
Check	0.00	x x x	x x x	3.7 e

1/ - Ratings based on a scale of 0 to 9 : 0 = dead grass or undesirable vegetative cover, 9 = excellent sward quality, <6 = unacceptable for roadsides.

2/ - An (X) indicates the presence of a particular item listing in a replication (three X's indicates presence in all three replications

3/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

Embark + Escort, HOE-704 + Escort, MON 4625 and HOE-740 at 0.89 lbs ai/A provided 90% or greater seedhead suppression at 11 WAT. Manage + Telar, ACP-1911X and HOE-704 + Telar provided an acceptable level of seedhead suppression (>75%). All other treatments did not provide an acceptable level of seedhead suppression (Table 9).

Table 9. Tall fescue seedhead suppression and broadleaf weed invasion 11 WAT.

TREATMENT	PRODUCT/A	SEEDHEAD SUPPRESSION 11 WAT	BROADLEAF WEEDS 11 WAT
		----%----	
Embark	24.0	36.7 de[1/]	15.3 a
Embark + Ferromec	24.0 + 96.0	23.3 ef	33.7 a
Embark + XE-1019	9.6 + 4.8	23.3 ef	2.3 a
Embark + XE-1019	9.6 + 8.0	40.0 de	2.3 a
Embark + Cutless	8.0 + 24.0	53.3 cd	13.3 a
Embark + Escort	9.6 + 0.20	96.3 a	2.3 a
Escort	0.25	71.7 abc	2.0 a
Manage + Telar	4.0 + 0.25	88.3 a	2.3 a
Roundup + Telar	4.0 + 0.25	81.7 ab	2.0 a
ACP-1911x	6.0	88.3 a	20.3 a
HOE-704	33.7	36.7 de	5.0 a
HOE-704	50.5	71.7 abc	17.0 a
HOE-704	68.2	90.0 a	28.3 a
HOE-704 + Telar	33.7 + 0.25	86.7 a	2.3 a
HOE-704 + Escort	33.7 + 0.125	95.0 a	2.3 a
HOE-704 + Embark	33.7 + 8.0	58.3 bcd	30.3 a
MON-4625	64.0	93.3 a	26.7 a
Check	0.00	0.0 f	26.7 a

1/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

Experiment 3

Objective

To evaluate the effects of several plant growth regulating compounds, and combinations thereof on the growth of a mowed turf stand.

Materials and Methods

A separate portion of the roadside used for experiments one and four was used for this experiment. The plots were 10 x 40 feet, and were arranged in a randomized complete block design with three replications. On May 18, 1987, the plot area was mowed with a rotary mower to a height of approximately six inches. Chemical treatments were applied on May 21 using the same procedures and equipment described in experiment one (Table 10).

Table 10. Materials and rates of application for Experiment 3.

Treatment	Ounces Product/Acre	Pounds Active Ingredient/A
Embark	24.0	0.38
Embark +	24.0	0.38
Ferromec	96.0	-.--
Embark +	8.0	0.12
Cutless	24.0	0.75
Embark +	6.0	0.10
XE-1019	8.0	0.25
Embark +	9.6	0.15
Escort	0.125	0.005
Manage +	4.0	0.19
Escort	0.33	0.013
Manage +	4.0	0.19
Telar	0.25	0.12
ACP-1911x	6.0	0.62
Check	0.00	0.00

The phytotoxic response to the treatments was evaluated at two weeks after treatment (WAT) using the same scale from experiments one and two. The overall appearance was rated five and eight WAT. The factors considered for the five WAT rating were phytotoxic response, annual grass, and broadleaf weed invasion. The same factors were considered for the eight WAT rating except tall fescue seedhead emergence was substituted for phytotoxic response.

Results and Discussion

The rating summary for overall appearance of the two, five, and eight WAT periods is shown in Table 11.

Table 11. Effect of PGR applied post mow to tall fescue roadside turf.

Treatment	Ounces Product/Acre	PHYTOTOXICITY[1/] 2 WAT	APPEARANCE[2/] 5 WAT	8 WAT
Embark	24.0	6.0 b[3/]	5.0 a	6.0 bc
Embark + Ferromec	24.0 + 96.0	6.3 b	6.0 a	6.2 b
Embark + Cutless	24.0 + 8.0	6.0 b	5.7 a	6.8 a
Embark + XE-1019	6.0 + 0.25 lbs. ai/A	6.3 b	4.0 a	5.5 cd
Embark + Escort	9.6 + 0.125	2.7 e	5.7 a	6.3 ab
Manage + Escort	4.0 + 0.33	2.7 e	3.0 a	6.0 bc
Manage + Telar	4.0 + 0.25	4.0 d	5.7 a	6.0 bc
ACP-1911x	6.0	5.0 c	4.3 a	5.3 d
Check	0.00	8.0 a	3.0 a	3.7 e

1/ - Ratings based on a scale of 0 to 9 : 0 = Dead grass, 9 = No Injury, <6 = Unacceptable for roadside turf

2/ - Ratings based on a scale of 0 to 9 : 0 = dead grass or undesirable vegetative cover, 9 = excellent sward quality, <6 = unacceptable for roadsides.

3/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

Injury two weeks after application was most severe for combination treatments which included sulfonyl urea products (Escort and Telar). ACP-1911x also caused unacceptable injury. All other treatments caused some injury when compared to untreated grass but were considered acceptable for roadside grasses. Although height measurement data are not shown, all treatments significantly suppressed foliar growth (22 to 31% when compared to untreated grass).

Five weeks after application, broadleaf weed invasion was found to be the greatest in untreated areas and areas treated with ACP-1911X. It appeared that ACP-1911X stimulated growth of crownvetch (similar results were found in experiment one). Treatments containing Escort or Telar provided the greatest control of broadleaf weeds (96%). Other treatments also provided significant broadleaf weed control when compared to the check (Table 12).

Table 12. Listing of components used in assigning a numerical appearance rating 5 WAT.

Treatment	Ounces Product/Acre	Broadleaf Weeds	Annual Grasses	T. Fescue Injury	Appearance[1/]
Embark	24.0	xxx[2/]	x		5.0 a[3/]
Embark + Ferromec	24.0 + 96.0	xx	xx	x	6.0 a
Embark + Cutless	8.0 + 24.0	xxx	x	xxx	5.7 a
Embark + XE-1019	6.0 + 0.25 lbs. ai/A	xxx	x	xxx	4.0 a
Embark + Escort	9.6 + 0.125	x	xx	xxx	5.7 a
Manage + Escort	4.0 + 0.33	xxx	x	xxx	3.0 a
Manage + Telar	4.0 + 0.25			x	5.7 a
ACP-1911x	6.0	xxx	x	x	4.3 a
Check	0.00	xxx			3.0 a

1/ - Ratings based on a scale of 0 to 9 : 0 = dead grass or undesirable vegetative cover, 9 = excellent sward quality, <6 = unacceptable for roadsides.

2/ - An (X) indicates the presence of a particular item listing in a replication (three X's indicates presence in all three replications

3/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

Eight weeks after application, evaluations for overall plot appearance were made (Table 13). These quality ratings were based on foliar discoloration, broadleaf weed and annual grass encroachment, and inconsistency of grass growth suppression. Untreated grass was rated unacceptable due to broadleaf weed invasion and the presence of seedheads that emerged after mowing. By this time, the grass had recovered from sulfonyl urea induced injury and broadleaf weeds were effectively controlled thus resulting in a desirable plot appearance. The Embark + XE-1019 treatment had an unacceptable level of foliar tip die-back. Swards treated with ACP-1911x were also considered unacceptable because of severe crownvetch encroachment in these areas.

Table 13. Listing of components used in assigning a numerical appearance rating 8 WAT.

Treatment	Ounces Product/Acre	Broadleaf Weeds	Annual Grasses	T.Fescue Seedhead	T. Fescue Injury	Appearance[1/]
Embark	24.0	xx [2/]	xx			6.0 bc [3/]
Embark + Ferromec	24.0 + 96.0	xx	xx			6.2 b
Embark + Cutless	8.0 + 24.0	xx			xx	6.8 a
Embark + XE-1019	6.0 + 0.25 lbs. ai/A	xx	xx		xx	5.5 cd
Embark + Escort	9.6 + 0.125		xxx			6.3 ab
Manage + Escort	4.0 + 0.33		xxx			6.0 b
Manage + Telar	4.0 + 0.25		xxx			6.0 b
ACP-1911x	6.0	xxx				5.3 d
Check	0.00	xxx	xxx	xxx		3.7 e

1/ - Ratings based on a scale of 0 to 9 : 0 = dead grass or undesirable vegetative cover, 9 = excellent sward quality, <6 = unacceptable for roadsides.

2/ - An (X) indicates the presence of a particular item listing in a replication (three X's indicates presence in all three replications

3/ - Means followed by the same letter within a column are not significantly different

(Duncan's New Multiple Range Test P= 0.05)

Visual estimates of the percent annual grass invasion were made after frost kill twenty-one weeks after treatment (Table 14). At this time, the brown annual grasses were easy to distinguish from the other vegetation. Stands that were treated with the sulfonyl urea products had the greatest percentage (>88%) of annual grasses. Similar results were found for experiment one. Embark alone and in combination with Ferromec also had significantly greater annual grass invasion when compared to the check. Embark in combination with Cutless and XE-1019 were not significantly different than the check. ACP-1911x had little annual grass invasion due to the significant invasion by crownvetch.

Table 14. Effect of PGR treatment applied post mowing on the encroachment by annual grasses rated 21 WAT.

Treatment	Ounces Product/Acre	Percent Annual Grass Cover
Embark	24.0	60.0 c [1/]
Embark + Ferromec	24.0 + 96.0	65.0 bc
Embark + Cutless	8.0 + 24.0	28.3 d
Embark + XE-1019	6.0 + 0.25 lbs. ai/A	28.3 d
Embark + Escort	9.6 + 0.125	88.3 ab
Manage + Escort	4.0 + 0.33	95.3 a
Manage + Telar	4.0 + 0.25	92.7 a
ACP-1911x	6.0	7.3 d
Check	0.00	14.0 d

1/ - Means followed by the same letter within a column are not significantly different (Duncan's New Multiple Range Test P= 0.05)

Experiments 4 and 5

Objective

To determine whether application method would effect the coverage and efficacy of Embark.

Materials and Methods

The experiments were conducted at two different locations. One was conducted near the same site of experiments one and three, and the other was conducted at the Penn State Horticulture Research Farm at Rock Springs. The treatments consisted of two different sizes of nozzles inserted in the Radiarc spray head, and a boom containing a set of flat fan nozzles. The nozzle sizes for the different treatments are listed below:

1. 13 - 0.030 Radiarc Nozzles
2. 13 - 0.045 Radiarc Nozzles
3. 13 - 8001 LP Flat Fan Nozzles

The flat fan nozzles were arranged along a boom according to specification. The radiarc head was orientated horizontally and the nozzles were arranged in the following fashion.

P = Plug	P N N N P P P N N N N
N = Nozzle	N N N P P P P N N N P

A consistent ten foot wide pattern was desired for each treatment. Embark was applied at 24 ounces of product per acre (0.375 ai/A) for all treatments in 30 gallons of water per acre (GPA).
Both experiments were evaluated in mid-summer by rating the suppression of tall fescue seedheads.

Results and Discussion

The seedhead suppression within the treatment area is shown in Table 15. The percentage of seedheads was lower in the flat fan nozzle treatment when compared to either of the Radiarc treatments. The boom mounted flat fan nozzles provided a consistent pattern throughout the target area. The two Radiarc treatments showed the same amount of seedhead suppression. These treatments demonstrated good seedhead suppression where the solution contacted the tall fescue foliage yet the spray pattern was inconsistent on the outside edge of target area. The outside edge formed a serpentine line of seedhead suppression within the plot area because the spray pattern was susceptible to any slight wind movement.

Table 15. The effect of application method on seedhead suppression of tall fescue using Embark PGR.

Treatment	Seedhead Suppression (%)
Flat Fan Boom	96.0 a
0.030 Radiarc	71.6 b
0.045 Radiarc	71.7 b
Check	00.0 c

An application using a different configuration of nozzles in the Radiarc head was conducted in a non-replicated demonstration near the area of experiment 5. The rate of Embark and GPA was the same as experiment 5. The Radiarc head was orientated in the vertical plane with the nozzles and plugs inserted as shown below. The width of the pattern was approximately 10 feet. This could be varied by raising or lowering the head along the mounting pole or by adding nozzles. This configuration demonstrated much better consistency throughout the target area than when orientated horizontally and was not as affected by wind movement.

PLUG = P
NOZZLES = 0.045
0.030

P	P
P	P
P	P
P	P
P	P
P	P
0.045	0.045
0.030	0.045
0.030	0.030
P	P
P	P

HERBACEOUS WEED CONTROL STUDY

Objective

To determine the efficacy of several herbicide compounds on herbaceous weed growth and also for their effects on the crownvetch or grass groundcover.

Materials and Methods

Four research trials were established to screen herbicides for weed control in crownvetch and grass. The materials and methods for all trials are discussed together, while the results and discussion of each trial will be presented separately. The locations were Philadelphia, Danville, State College and Snow Shoe. These locations represented rather diverse soil, environmental and growing conditions. Although soils are so mixed up along roadsides it is impossible to characterize them by name, they can be characterized by parent material and drainage. The Philadelphia trial was on a well drained soil derived from schist, gneiss and quartzite. The soils at the Danville and State College sites are both derived from limestone but the Danville site was poorly drained and State College site well drained. The Snow Shoe site has soil derived from sandstone and was well drained. Results from a soil test taken at the Danville, State College and Snow Shoe sites are presented in the Table 1. Soil was not tested from the Philadelphia site.

Table 1. Soil test data from Danville, State College, and Snow Shoe.

Soil Nutrient Levels	Danville	State College	Snow Shoe
Soil pH	6.4[1]	7.7[3]	6.1[1]
Available phosphate	30 lb/A[1]	154 lb/A[2]	27 lb/A[1]
Available potash	262 lb/A[2]	571 lb/A[2]	215 lb/A[2]
Available Mg	461 lb/A[2]	1496 lb/A[3]	276 lb/A[2]

[1] Low for crownvetch growth
[2] Optimum for crownvetch growth
[3] High for crownvetch growth

The soil test would indicate that the soil pH was a little low and the available phosphate very low for optimum crownvetch growth at both the Danville and Snow Shoe sites. This might explain why the crownvetch that had been seeded at both of these sites was not doing well and weeds are now dominate. Also the poor drainage at the Danville site would contribute to the loss or poor establishment of the crownvetch stand at this site.

Twenty two to 36 herbicide treatments were applied to each of the sites in a randomized complete block design with three replications. Plot size was 21 by 25 ft. in Philadelphia, 15 by 25 ft. in Danville and State College, and 10 by 30 ft. in Snow Shoe. Herbicide treatments were chosen based on their performance in screening trials conducted in 1985 and '86 plus any others that were thought to have potential for controlling Canada thistle or other herbaceous weeds in crownvetch. Most treatments were applied either early in the spring just as the weeds were breaking dormancy or at a time that would be close to the Canada thistle bud stage, although very little Canada thistle was actually present at any of the sites. The early application dates ranged from April 8 in Philadelphia to April 29 in Snow Shoe. The Canada thistle bud stage treatments ranged from June 3 in Philadelphia to June 6 in Snow Shoe. The June 6 treatments in Show Shoe were probably a bit early relative to those in Philadelphia. Crownvetch and weed growth at the time of treatment are shown in Table 2.

Table 2. Size of crownvetch and other weeds at Philadelphia, Danville, State College, and Snow Shoe at the time of herbicide application.

Plant Species & Application Date	Site of Trials Phil.	Danville	S College	Snow Shoe
Crownvetch (Apr. 8 - 29)	Dormant	Dormant	Dormant	Dormant
Goldenrod (Apr. 8 - 29)	None	0 - 3 in.	None	0 - 2 in.
Grasses (Apr. 8 - 29)	None	None	Dormant	Dormant
Crownvetch (June 3 - 6)	36 in.	24 -36 in.	24 -30 in.	14 -18 in.
Goldenrod (June 3 - 6)	None	12 - 36 in.	None	6 - 12 in.
Grasses (June 3 - 6)	None	None	24 - 35 in.	12 - 18 in.

All treatments were applied with a small plot sprayer. Most treatments were applied with 8001 LP flat fan TeeJet tips at 19 psi pressure in 10 to 40 gal/A of water. The low herbicide rate was usually applied in 10 gal, medium rate in 20 gal, and high rate in 40 gal. of water.

The criteria used to evaluate the treatments are as follows:

a. total weed control without any injury to the crownvetch
b. total weed control with some temporary burning or stunting of the crownvetch.
c. 75 to 95% weed control with no injury to the crownvetch.
d. 75 to 95% weed control with temporary burning or stunting of the crownvetch.
e. <75% control of one or more key weed species with no injury to the crownvetch.
f. <75% control of one or more key weed species with temporary burning or stunting of the crownvetch.
g. very little weed control and no injury to the crownvetch.
h. very little weed control with temporary burning or stunting of the crownvetch.

The total control of all weeds without injury to the crownvetch is not likely but still should be the ultimate goal. Anything less than 75% control of key weeds (Canada thistle and others as yet undefined) one year after treatment is unacceptable. Some temporary burning or stunting from which the crownvetch recovers in a few weeks is tolerable as long as the control of key weeds is still 75% or more one year after treatment.

Of secondary importance is the time of year when the treatment can be applied. Ideally treatments applied at a time of year when crop, garden, or landscape plants are not present or sensitive would be preferred. This would be in the fall, winter or early spring when these plants are dormant. The next best time would be after the weeds have broken dormancy but before they have made much growth so the dead skeletons are not obvious after the treatment and the desirable cover has a chance to fill in before the summer is over. The least desirable time of application would be in the middle of summer when most other non-target plants are present and sensitive, dead weed skeletons are large, the potential for undesirable brownout are greater, and the desirable cover may not have time to fill in the open areas left by the weeds. All herbicides used in this study are listed below in Table 3. All herbicides will be referred to as the product name.

Table 3. Herbicide names, formulation, and manufacturer used for all experiments.

Product Name	Common Name	Formulation	Manufacturer
"Numerous"	Dichlobenil	4 G	Numerous
Arsenal	Imazapyr	2#/Gallon	American Cyanamid Co.
Basagran	Bentazon	4#/Gallon	BASF Corporation
Laddok	Atrazine + Bentazon	1.67#/Gallon 1.67#/Gallon	BASF Corporation
Lontrel	XRM-3472 Clopyralid		Dow USA Inc.
Pursuit	Imazethapyr	2#/Gallon	American Cyanamid Co.
Roundup	Glyphosate	4#/Gallon	Monsanto Co.
Velpar	Hexazinone	2#/Gallon	E.I. Dupont de Nemours Co.

Philadelphia Site

Results and Discussion

The trial in Philadelphia had very few weeds so the results best tell us how safe the various treatments are on crownvetch. Crownvetch injury was determined at this location by visually estimating percent crownvetch ground cover on June 13 and October 15 (Table 4). This was the only location where dichlobenil (Casoran, Norasac) was tested. Dichlobenil is labeled for annual and perennial weed control in ornamental nursery stock and is usually applied as a granule in the fall of the year. It is rather volatile so application under cool conditions in the late fall reduces the volatility loss until it is leached into the soil by rain or melting snow. It is known to control Canada thistle, bindweeds and other perennials at rates of 2 to 4 lb ai/A. These rates appeared to be totally safe on crownvetch. Arsenal was inadvertently sprayed on treatment number 2, yet the crownvetch was not severely injured. The data would suggest the Arsenal had been applied to treatment 1 since crownvetch growth was suppressed early in the season, typical of the activity of other Arsenal treated plots.

Arsenal applied on April 8 severely suppressed crownvetch growth early in the year but it totally recovered by Oct. 15. The high rate (T6) inhibited all new growth until the middle of June which is not desirable. The lowest rate (T4) and quite possibly even half this rate (.0625 lb ai/A) would be enough to suppress the weeds with only temporary stunting of the crownvetch. This is also at a time of year when very few sensitive plants are growing, there would be no dead skeletons or brownout as a result of treatment and the crownvetch apparently totally recovers by late summer or fall.

Arsenal applied on June 3 (T13-15), caused severe injury to the crownvetch, particularly at the high rate, within 10 days after treatment (June 13). Even if the weed control were excellent, this kind of effect on the crownvetch is unacceptable. Therefore, Arsenal applied in late spring or summer is not the best time.

Pursuit belongs to the same herbicide family as Arsenal but is much less active on crownvetch (T7-9) and (T16-18). It did appear to cause some injury to the crownvetch at the high rate when applied in summer (T18) but it totally recovered by Oct. 15. Although Pursuit is the safest of the herbicides tested on Crownvetch, it does not have enough activity on perennial weeds to use it this way as will be noted from results at other sites.

Velpar applied April 8 (T10-12) caused little or no injury to crownvetch at rates up to 1 lb ai/A. When applied at 2 lb ai/A, crownvetch still totally recovered by Oct. 15. Velpar applied on June 3 caused crownvetch injury at all rates (T19-21) when rated June 13 but also totally recovered by Oct. 15. As will be seen from results at other sites, Velpar applied both early or late spring gave excellent control of a broad spectrum of perennial weeds. Velpar will also provide some control of woody perennials when applied at the higher rates in late spring.

Table 4. Herbaceous Weed Control in Crownvetch - 1987 (Philadelphia, PA)

Treatment	Application Rate (lb ai/A)	Application Date	Percent Crownvetch Cover 6/13/87	Percent Crownvetch Cover 10/15/87
1. dichlobenil 4G	2	Dec. 17	47 def[1]	81 a-d
2. dichlobenil 4G + Arsenal	3 + 0.25	Dec. 17 + Apr. 8	84 a	87 ab
3. dichlobenil 4G	4	Dec. 17	88 a	85 ab
4. Arsenal	0.125	April 8	45 efg	89 a
5. Arsenal	0.25	April 8	20 i	76 bcd
6. Arsenal	0.5	April 8	2 j	81 a-d
7. Pursuit	0.125	April 8	87 a	81 a-d
8. Pursuit	0.25	April 8	88 a	83 abc
9. Pursuit	0.5	April 8	72 abc	83 abc
10. Velpar	0.5	April 8	76 ab	88 ab
11. Velpar	1	April 8	81 a	83 abc
12. Velpar	2	April 8	55 de	85 ab
13. Arsenal	0.125	June 3	76 ab	71 d
14. Arsenal	0.25	June 3	31 ghi	53 e
15. Arsenal	0.5	June 3	55 de	14 f
16. Pursuit	0.125	June 3	78 ab	82 a-d
17. Pursuit	0.25	June 3	76 ab	72 cd
18. Pursuit	0.5	June 3	62 bcd	81 a-d
19. Velpar	0.5	June 3	59 cde	86 ab
20. Velpar	1	June 3	36 fgh	87 ab
21. Velpar	2	June 3	28 hi	89 a
22. Untreated Check	- - -	- - -	83 a	83 abc

[1] Column means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Danville Site

In Danville the primary weed problem was goldenrod and although the crownvetch was sparse, there was some in almost every plot. Percent control of both goldenrod and crownvetch was visually rated on June 23 and September 29 (Table 5). Control estimates were a combination of herbicide injury and reduction in stand. When only a few plants were present in the plot, percent control was based on apparent injury or stunting of those few plants.

Arsenal applied on April 20 (T1-3) severely injured the crownvetch, and it didn't appear to recover by Sept. This is quite different from the Philadelphia site where the crownvetch totally recovered by fall from even the highest rate of Arsenal. The biggest difference between the two sites was the excellent crownvetch stand in Philadelphia versus a very weak stand of crownvetch in Danville. It would be expected that Arsenal would cause more injury on weak crownvetch. If a very low rate were used (.0625 lb ai/A) as suggested before, there would be less crownvetch injury but also almost no control of goldenrod. Effective control of goldenrod was only apparent at the higher rates.

Arsenal applied on June 5 (T10-12) also caused substantial injury to the crownvetch. This is similar to the results obtained in Philadelphia. Goldenrod was not effectively controlled when applied in late spring regardless of rate.

Pursuit was reasonably safe on the crownvetch whether applied on April 20 or June 5 but it also was ineffective in controlling the goldenrod. The best activity on goldenrod was noted at the highest rate when applied on April 20 (T6) however, the goldenrod had recovered by Sept. 29.

Velpar applied April 20 (T 7-9) only slightly injured the crownvetch when rated on June 23. However the injury was much greater when rated on Sept. 29. This response is contrary to the results noted in Philadelphia in which the crownvetch had significantly recovered from the treatment by the later rating date. The best treatment when considering optimum goldenrod control with tolerable crownvetch injury was Velpar applied on June 5 at the 1 lb ai/A rate (T17).

Clopyralid (XRM-3972) is a growth hormone type herbicide similar to triclopyr (Garlon) and is known to be very active on Canada thistle. However, control of goldenrod was poor, slow to develop, and not nearly as effective as the Velpar treatments. In this experiment, Clopyralid produced 50-70% control of the crownvetch on Sept. 29. Information from the Canada thistle control study indicates complete recovery of crownvetch one year after treatment when a similar rate was applied. The injury to crownvetch in this experiment however, was unacceptable.

Basagran is a contact herbicide with some residual activity as a photosynthetic inhibitor. It also has activity on Canada thistle but usually requires a split treatment to be effective. Single treatments (T22,23) didn't cause excessive injury to crownvetch but the split treatment (T24) caused unacceptable injury. In addition, goldenrod control was very poor.

Laddok is a mixture of Basagran and atrazine at 1.67 lb ai/gal of each. This combination is even better on Canada thistle than Basagran alone and adequate control can usually be obtained with a single treatment. Crownvetch injury was only slightly greater than Basagran alone when applied at the equivalent rate (T23 vs. T26). Goldenrod control was very poor at even the highest rate.

Table 5. Herbaceous Weed Control in Crownvetch - 1987 (Danville, PA)

Treatment Herbicide	Application Date	Application Rate(lb ai/A)	Percent Crownvetch Control 6/23/87	Percent Goldenrod Control 6/23/87	Percent Crownvetch Control 9/29/87	Percent Goldenrod Control 9/29/87	
1. Arsenal	April 20	0.125	94 a[1]	83 ab	60 a	34 a-e	
2. Arsenal	April 20	0.25	100 a	94 a	95 a	46 a-e	
3. Arsenal	April 20	0.5	100 a	99 a	89 a	97 ab	
4. Pursuit	April 20	0.125	2 cd	47 cd	5 a	35 a-e	
5. Pursuit	April 20	0.25	18 cd	43 cde	60 a	32 a-e	
6. Pursuit	April 20	0.5	43 bcd	88 a	37 a	32 a-e	
7. Velpar	April 20	0.5	5 cd	7 ef	75 a	20 cde	
8. Velpar	April 20	1	2 cd	40 cde	88 a	43 a-e	
9. Velpar	April 20	2	33 bcd	100 a	63 a	75 abc	
10. Arsenal	June 5	0.125	15 cd	25 c-f	65 a	57 a-e	
11.	Arsenal	June 5	0.25 13	cd 20	c-f 65	a 85	abc
12.	Arsenal	June 5	0.5 50	bc 12	def 93	a 60	a-e
13. Pursuit	June 5	0.125	28 bcd	15 def	32 a	25 cde	
14.	Pursuit	June 5	0.25 18	cd 8	ef 72	a 35	a-e
15.	Pursuit	June 5	0.5 3	cd 8	ef 50	a 30	b-e
16.	Velpar	June 5	0.5 5	cd 47	cd 53	a 72	abc
17.	Velpar	June 5	1 10	cd 87	a 45	a 95	ab
18.	Velpar	June 5	2 25	bcd 92	a 90	a 99	a
19. XRM-3972	June 5	0.1	13 cd	13 def	60 a	25 cde	
20.	XRM-3972	June 5	0.2 35	bcd 15	def 50	a 30	b-e
21.	XRM-3972	June 5	0.4 5	cd 23	c-f 70	a 70	a-d
22. Basagran	June 5	1	10 cd	33 c-f	0 a	43 a-e	
23.	Basagran	June 5	2 50	bc 20	c-f 35	a 0	e
24.	BasagranJune 5 + June 2		31 + 2	95 a	53 bc	90 a	
33	a-e						
25. Laddok	June 5	2	30 bcd	15 def	37 a	0 e	
26.	Laddok	June 5	4 70	ab 25	c-f 35	a 3	de
27. Untreated Check	- - -	- - -	0 d	0 f	33 a	0 e	

[1] Column means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

State College Site

Results and Discussion

The State College site had a thin stand of crownvetch similar to the Danville site and it appeared to be well drained. There was also more perennial grass than at the Danville site but not enough to allow statistical analysis of the results. Therefore, only the crownvetch data is presented in Table 6 and the effects of the treatments on grass will be discussed where appropriate.

The low rate of Arsenal applied at either date was the only rate that the crownvetch tolerated (T1,10). This same effect was also noted at the Danville site. Higher rates caused excessive injury throughout the season(T2,3,11,12). Grass suppression was excellent when rated on June 22 but had recovered substantially by Sept. 11. An item of interest was that birdsfoot trefoil didn't appear to be affected by the the low rate and although there was suppression at the medium and high rates on June 22, it recovered totally by Sept. 11.

Pursuit was totally safe on crownvetch at all rates whether applied on April 14 or June 6. Grass control was poor and it had no effect on any broadleaved weeds or birdsfoot trefoil regardless of rate.

All rates of Velpar applied either April 14 or June 6 gave excellent grass control. Velpar caused little injury to crownvetch at the 0.5 and 1.0 lb rates when applied April 14 or the 0.5 lb rate applied June 6. The 2 lb rate applied June 6 produced unacceptable crownvetch injury.

Clopyralid (XRM-3972) reduced crownvetch growth 60% even at the lowest rate by Sept. 11 (T19). It had about an equal effect on broadleaved weeds and no effect on grasses. This herbicide could probably be used for Canada thistle and other broadleaf weed control in a grass groundcover but it is probably not safe enough to be used on crownvetch.

Basagran was reasonably safe on crownvetch at all rates but it did not control any of the perennial broadleaved weeds or grasses present (T22-24). At this particular site it appeared to have little value.

Laddok (Basagran + atrazine) appeared to be safe on crownvetch even at the highest rate (T26). It was also only at this rate that it provided some perennial broadleaf and grass control which was primarily from the atrazine in the mixture.

Table 6. Herbaceous Weed Control in Crownvetch - 1987 (State College, PA)

Treatment	Timing	Rate (lb ai/A)	Percent Crownvetch Injury 6/22/87	Percent Crownvetch Injury 9/11/87
1. Arsenal	April 14	0.125	78 ab[1]	20 def
2. Arsenal	April 14	0.25	99 a	63 abc
3. Arsenal	April 14	0.5	100 a	95 a
4. Pursuit	April 14	0.125	2 g	17 ef
5. Pursuit	April 14	0.25	0 g	7 ef
6. Pursuit	April 14	0.5	7 fg	3 f
7. Velpar	April 14	0.5	7 fg	7 ef
8. Velpar	April 14	1	3 g	7 ef
9. Velpar	April 14	2	77 ab	38 c-f
10. Arsenal	June 6	0.125	23 efg	47 b-e
11. Arsenal	June 6	0.25	18 efg	82 ab
12. Arsenal	June 6	0.5	32 def	90 a
13. Pursuit	June 6	0.125	0 g	10 ef
14. Pursuit	June 6	0.25	5 fg	17 ef
15. Pursuit	June 6	0.5	13 efg	30 c-f
16. Velpar	June 6	0.5	7 fg	8 ef
17. Velpar	June 6	1	63 bc	12 ef
18. Velpar	June 6	2	68 b	63 abc
19. XRM-3972	June 6	0.1	18 efg	60 a-d
20. XRM-3972	June 6	0.2	40 cde	93 a
21. XRM-3972	June 6	0.4	57 bcd	100 a
22. Basagran[2]	June 6	1	3 g	35 c-f
23. Basagran[2]	June 6	2	10 fg	7 ef
24. Basagran[2]	June 6 + June 23	2 + 1	40 cde	20 def
25. Laddok[2,3]	June 6	2	5 fg	30 c-f
26. Laddok[2,3]	June 6	4	15 efg	5 ef
27. Untreated Check	---	---	2 g	7 ef

[1] Column means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

[2] Includes crop oil concentrate at 1 quart/acre, 1.25% (v/v).

[3] Laddok is a premix of bentazon + atrazine at 1.67 + 1.67 lb/gallon.

Snow Shoe Site

Results and Discussion

The Snow Shoe site was quite different than the other three sites in that the crownvetch and weeds were not as large when treated and growth was not as active due to poor growing conditions. There was however, a good stand of crownvetch, grass and goldenrod in all plots. Included at this site were six Roundup and three atrazine treatments applied on June 6 which were not included at the other sites. Roundup is generally considered to be non-selective when applied to the foliage of plants but from past experience, crownvetch has recovered from treatments up to 1 lb ai/A. Treatments also included the addition of ammonium sulfate to the Roundup which can increase activity on hard to control weeds.

Arsenal even at the lowest rate caused excessive crownvetch injury when applied April 29 (T1). At the same application date, grass and goldenrod growth was suppressed on July 6 but both had recovered by Oct. 7. At higher rates the grass control was good all season but the goldenrod control was still poor (Table 7).

Arsenal applied on June 6 was safer on crownvetch at all rates (T10-12) than that applied April 29. This was similar to the result found at Danville and State College. It might be due to poor growing conditions that Arsenal was not as active on crownvetch as it was in Philadelphia. It was also not very active on either the grass or the goldenrod. A rate that will control weeds without injury to crownvetch does not seem possible with Arsenal under these conditions.

Pursuit didn't cause excessive injury to crownvetch at any rate or time of application, but it also didn't effectively control either grass or goldenrod. This is consistent with results at the other sites.

Velpar applied on April 29 was safe on crownvetch at all rates (T7-9) but only the highest rate provided effective grass and goldenrod control (T9). Velpar applied post (June 6) was also reasonably safe on crownvetch at all rates (T16-18) but here also it took the highest rate to provide effective grass and goldenrod control all season (T18). A higher rate of Velpar was necessary to provide adequate weed control in Snow Shoe than was the case in Danville or State College.

Clopyralid (XRM-3972) caused excessive injury to crownvetch at all rates by Oct. 7. Control of goldenrod was poor even at the highest rate and there was no effect on grass as would be expected from a growth hormone type herbicide.

Roundup applied alone on June 6 (T22-24) caused excessive injury to crownvetch at all rates. Although the grass and goldenrod control was fair on July 6, regrowth of both was excessive by Oct. 7. With the addition of ammonium sulfate (T25-27), Roundup activity on crownvetch was reduced at the low rate and remained about the same at the higher rates. Grass and goldenrod control was not improved. The use of Roundup should be limited to control of only those weeds that cannot be controlled by any other means and the excessive crownvetch injury will have to be tolerated.

Atrazine is commonly used by crownvetch seed growers to clean up seed fields. It works very well for quackgrass and other cool season grasses but misses warm season grasses (johnsongrass, switchgrass etc.) and deep rooted broadleaves. In this trial, atrazine was reasonably safe on crownvetch up to the highest rate of 4 lb ai/A (T30). The high rate was the only rate that provided adequate grass and goldenrod control.

Atrazine may work better if tank mixed with other herbicides such as Arsenal or Velpar so lower rates can be used without sacrificing weed control. One might also use simazine (same herbicide family as atrazine) with Arsenal or Velpar.

Single treatments of Basagran (T31,32) was very safe on crownvetch but the split treatment caused unacceptable injury (T33). However, Basagran had no effect on the type of weeds present at this site. These same results were also noted at the Danville and State College sites.

Laddok (Basagran + atrazine) was safe on crownvetch at the low rate but was caused unacceptable injury to crownvetch at the high rate. This was not true at the Danville and State College sites which would indicate that the crownvetch in Snow Shoe was more sensitive and less vigorous than at the other sites. Grass and goldenrod control was poor even at the high rate. It would appear that Laddok can be effective for Canada thistle control but very few other weeds.

Summary

Dichlobenil showed excellent safety on crownvetch at the Philadelphia site and except for the cost would probably be an excellent treatment for weed control in healthy crownvetch. It was not tested at other locations where the crownvetch was not as vigorous.

Arsenal also showed excellent safety on crownvetch at 0.125 lb ai/A when applied in April at all sites except Snow Shoe. I feel this is one of the best treatments for the cost and a rate of .0625 lb ai/A should be used where crownvetch does not grow well. The introduction of birdsfoot trefoil can be considered where other ground cover is not doing well since Arsenal at rates up to 0.25 lb ai/A has almost no effect on it. The lowest Arsenal rates are not suppressing grasses, goldenrod and other perennial weeds all summer so a follow-up treatment of something like Velpar in late spring or summer may be needed to achieve the desired control. These tests indicate that Arsenal applied in late spring or summer caused unacceptable injury the crownvetch.

Velpar is the only other treatment tested that looks promising for general weed control in crownvetch. Velpar applied in April appeared to be safe on crownvetch up to 2 lb ai/A at Philadelphia and Snow Shoe but not Danville or State College. Velpar applied in June to crownvetch that had 1 to 3 feet of growth was usually safe at rates up to 1 lb ai/A at all sites. Grass, goldenrod and other weed control was generally excellent from this treatment. This treatment also provides excellent control of Canada thistle. Velpar at 2 lb ai/A also provided excellent grass, goldenrod and other weed control, but injury to crownvetch was noted at this rate.

Laddok (Basagran + atrazine) applied in June was safe on crownvetch at the low rate of 1 + 1 lb ai/A with crop oil concentrate at 1 qt/A. Although it didn't control grass or goldenrod, weeds common to these sites, it is known to give excellent control of Canada thistle at this rate. It can be used where Canada thistle is the major weed problem and both crownvetch and grass are the groundcover.

Table 7 - Herbaceous Weed Control in Crownvetch - 1987 (Snow Shoe, PA)

Treatment	Application Date[1]	Rate (Lb. ai/A)	Rated 7/6/87 Percent Crownvetch Injury		Rated 7/6/87 Percent Grass Control		Rated 7/6/87 Percent Goldenrod Control		Rated 10/7/87 Percent Crownvetch Injury		Rated 10/7/87 Percent Grass Control		Rated 10/7/87 Percent Goldenrod Control	
1. Arsenal	April 29	0.125	78	ab[2]	82	abc	67	abc	62	a-e	33	cd	27	bcd
2. Arsenal	April 29	0.25	97	a	98	a	98	a	87	ab	97	a	43	a-d
3. Arsenal	April 29	0.5	99	a	99	a	97	a	89	ab	50	bcd	33	bcd
4. Pursuit	April 29	0.125	23	efg	74	abc	18	c-f	18	def	0	d	0	d
5. Pursuit	April 29	0.25	12	fg	30	d-g	20	c-f	40	b-f	0	d	17	cd
6. Pursuit	April 29	0.5	60	bcd	81	abc	65	a-d	43	a-f	0	d	37	bcd
7. Velpar	April 29	0.5	8	fg	30	d-g	27	c-f	5	f	0	d	0	d
8. Velpar	April 29	1	22	fg	95	ab	98	a	20	def	0	d	50	a-d
9. Velpar	April 29	2	25	efg	100	a	99	a	30	c-f	--	--	90	ab
10. Arsenal	June 6	0.125	25	efg	20	efg	20	c-f	15	ef	17	d	40	a-d
11. Arsenal	June 6	0.25	25	efg	3	g	18	c-f	50	a-f	23	cd	70	abc
12. Arsenal	June 6	0.5	65	bc	32	d-g	35	c-f	93	a	42	cd	57	a-d
13. Pursuit	June 6	0.125	10	fg	3	g	0	f	10	f	0	d	0	d
14. Pursuit	June 6	0.25	23	efg	8	fg	0	f	10	f	0	d	0	d
15. Pursuit	June 6	0.5	23	efg	28	d-g	27	c-f	10	f	0	d	32	bcd
16. Velpar	June 6	0.5	5	fg	5	g	42	b-f	10	f	0	d	33	bcd
17. Velpar	June 6	1	37	def	98	a	99	a	68	a-d	70	abc	66	abc
18. Velpar	June 6	2	25	efg	99	a	99	a	42	a-f	90	ab	100	a
19. XRM-3972	June 6	0.1	28	efg	0	g	8	ef	85	ab	0	d	0	d
20. XRM-3972	June 6	0.2	53	b-e	0	g	10	ef	85	ab	0	d	17	cd
21. XRM-3972	June 6	0.4	80	ab	0	g	23	c-f	--	--	0	d	68	abc
22. Roundup	June 6	0.5	80	ab	75	abc	67	abc	80	abc	10	d	50	a-d
23. Roundup	June 6	1	98	a	80	abc	50	a-f	85	ab	25	cd	0	d
24. Roundup	June 6	2	99	a	96	ab	56	a-e	83	ab	25	cd	7	cd
25. Roundup[3]	June 6	0.5	18	fg	10	fg	28	c-f	25	def	0	d	7	cd
26. Roundup[3]	June 6	1	78	ab	63	a-d	30	c-f	85	ab	35	cd	33	bcd
27. Roundup[3]	June 6	2	81	ab	94	ab	37	b-f	85	ab	38	cd	33	bcd
28. atrazine[4]	June 6	1	8	fg	0	g	0	f	15	ef	0	d	0	d
29. atrazine[4]	June 6	2	13	fg	49	c-f	35	c-f	7	f	0	d	0	d
30. atrazine[4]	June 6	4	33	d-g	98	a	88	ab	48	a-f	43	cd	88	ab
31. Basagran[4]	June 6	1	3	g	0	g	2	ef	17	ef	0	d	0	d
32. Basagran[4]	June 6	2	12	fg	0	g	10	ef	7	f	0	d	0	d
33. Basagran[4]	June 6 + July 6	1 + 2	12	fg	0	g	12	def	65	a-e	0	d	17	cd
34. Laddok[4]	June 6	1 + 1	15	fg	17	efg	10	ef	10	f	0	d	0	d
35. Laddok[4]	June 6	2 + 2	5	fg	53	b-e	20	c-f	80	abc	0	d	0	d
36. Untreated Check		- - -	2	g	0	g	0	f	45	a-f	0	d	0	d

[1] June 6 treatments received rainfall within six hours of application.

[2] Column means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

[3] Treatments 25-27 included ammonium sulfate at 2%(w/w).

[4] Atrazine, Basagran, and Laddok treatments include Crop Oil Concentrate at 5% (v/v).

CROWNVETCH ESTABLISHMENT EXPERIMENT

Objective

To determine the influence of reseeding crownvetch into areas where none or little exists after brush and weeds have been partially or totally controlled by herbicides.

Materials and Methods

This trial was conducted on Brush Valley Road in Centre County. Various herbicide treatments had been applied in June and September of 1986 for herbaceous weed and brush control. On May 6, 1987, crownvetch was broadcast with a cyclone seeder at a rate of 3 lb/A to the two replications on the north side of the road. To stimulate crownvetch seedling growth, 250 lb/A of 10-30-10 fertilizer was applied to the same area with the same cyclone seeder. To control annual grasses and some broadleaved weeds, Prowl at 2 lb ai/A was applied with the radiarc in 15 gallon of water on May 6.

Results and Discussion

Crownvetch starts very slowly, but crownvetch seedlings were so sparse that they were hardly noticeable when ratings were made in August. Where brush control was the best from the 1986 treatments, annual grasses were dominating. The Prowl was apparently applied to late for effective grass control.

Summary

As a result of poor brush control in some plots and uncontrolled annual grasses in others, the crownvetch seedlings are suffering from excessive competition and the stand is extremely sparse at best. Perhaps in time (3 to 5 years) the crownvetch might start to fill in and crowd out the annual weeds but at the moment it doesn't look promising.

CANADA THISTLE CONTROL STUDY

The perennial weed Canada thistle [Cirsium arvense (L.) Scop.] growing in crownvetch, (Coronilla varia L.) is a maintenance problem on roadsides throughout the state of Pennsylvania. The objective of this study is to determine the most effective program for controlling Canada thistle in crownvetch along Pennsylvania roadsides. Several experiments were conducted to achieve this goal.

Experiment one was performed in Elizabethtown, Lancaster County where crownvetch was the established groundcover. Several herbicides were evaluated for their ability to control Canada thistle and their effect on crownvetch.

Experiment two located in State College, Centre County, evaluated several herbicides for their efficacy in controlling Canada thistle. Groundcover at this site was a mixture of crownvetch and grass. Because the dominant species varied from plot to plot, treatment related activity on the groundcovers could not be evaluated. Therefore, the activity of the treatments on the Canada thistle was the only parameter measured.

Experiment three, located in Danville, Montour County, evaluated the performance of several herbicide treatments when applied to a pure stand of crownvetch. By treating a pure stand of crownvetch with a variety of herbicide treatments, information describing the tolerance of the crownvetch to those treatments was obtained.

Experiment four, located in Bellefonte, Centre County, measured the level of total nonstructural carbohydrates (energy reserves) of the Canada thistle plant throughout an entire growing season and determine the best time for herbicide application. Both herbicide treated plants and non-treated plants were evaluated. This experiment, located on I-80 in Centre County, was initiated in October of 1986 and was completed in September of 1987.

When working with perennial plants such as Canada thistle that have an extensive root system and high levels of total nonstructural carbohydrates, control ratings for the first season after a control measure has been applied can be misleading. Canada thistle has the ability to produce new shoots from its underground root system. No herbicide treatment applied to Canada thistle gave complete control and new aboveground regrowth appeared the same season as treatment application. Although these plants may look healthy when this initial regrowth occurs, they may be in an energy depleted state and may not be able to survive the winter. Therefore, recommendations made during the first year of treatment are misleading and premature. Only when stand counts and ratings can be taken as regrowth appears can a firm conclusion be established. Control ratings the second year are the true test of the efficacy of an herbicide on Canada thistle. The herbicides used in this study are listed in Table 1 by product name, common name, formulation, and manufacturer. These treatments will be referred to by product name.

Table 1. Herbicide names, formulation, and manufacturer for Experiment 1.

Product Name	Common Name	Formulation	Manufacturer
Numerous	atrazine	4#/Gallon	Numerous
Arsenal	Imazapyr	2#/Gallon	American Cyanamid

Banvel 720	Dicamba + 2,4-D	1#/Gallon 1.9#/Gallon Amine	Sandoz Crop Protection Co.
Crossbow	Triclopyr + 2,4-D	1#/Gallon 2#/Gallon Ester	Dow USA Inc.
Dyrene	Anilazine	4#/Gallon	Mobay
Escort	Metsulfuron methyl	60 DF	E.I.Dupont De Nemours Co.
Garlon 4	Triclopyr	4#/Gallon Ester	Dow USA Inc.
Lontrel	Clopyralid	3#/Gallon	Dow USA Inc.
Roundup	Glyphosate	4#/Gallon	Monsanto Co.
Oust	Sulfometuron methyl	75 DF	DuPont
Velpar	Hexazinone	2#/Gallon	DuPont
Weedone 170	2,4-DP + 2,4-D	1.85#/Gallon Ester 1.85#/Gallon Ester	Union Carbide

EXPERIMENT 2

Objective

To rate several herbicide treatments for their effectiveness in controlling Canada thistle.

Materials and Methods

Trials were established in State College (Centre County). Treatments were selected from a review of currently available herbicides and from the list of control measures currently used by Penn DOT personnel. Nine treatments were selected and applied on June 10, 1986 at the late bud stage of Canada thistle. All treatments were applied broadcast with a hand held boom in the equivalent of 12 gallons of water per acre. Plots measured 8 feet by 25 feet and were arranged in a randomized complete block design. Groundcover at this site was a mixture of crownvetch and grass. Because the dominant species varied from plot to plot, treatment related activity on the groundcovers could not be measured. Therefore, the activity of the treatments on the Canada thistle was the only parameter evaluated. Control was also visually rated throughout 1986. Canada thistle stem counts were taken in May 1986 before treatment application and again on the regrowth one year later in May 1987 to determine the effectiveness of each treatment. The treatments were reapplied at the same rate to the same plots on June 11, 1987 to determine the efficacy of two consecutive annual treatments. In addition, Dyrene at 3.0 and 6.0 lbs ai/A, was also applied to previously untreated plots on June 11 and July 7, 1987 respectively. The results of all treatments will be measured May 1988 when regrowth appears aboveground.

Results and Discussion

Table 3 presents the results of the Canada thistle stem counts taken in the spring of 1987. The means for each treatment were analyzed using Duncan's New Multiple Range Test at the 5% level. This study had a cv of 51%. This variation in the stand ratings was due to the creeping growth habit of Canada thistle. The nature of this type of growth can cause the stand density of untreated thistles in a particular quadrant to both increase and decrease over time. By determining the regrowth a year after application and using this parameter to measure treatment efficacy, most of the treatments demonstrated a high degree of control to Canada thistle.

Escort, Garlon plus Banvel 720, and the mechanically cut gave statistically the same amount of control as the untreated check. Atrazine, Arsenal, clopyralid, Crossbow, Velpar, and Escort plus Roundup all produced a high level of control to Canada thistle. Although, these six treatments gave an adequate level of control, ranging from 67 to 78%, the effects of these herbicides on crownvetch must be taken into account.

Table 3. **Canada Thistle Control**

Route 322 By-Pass; State College, PA

Treatment				Thistle
No.	Herbicide	Stage[1]	Rate	Stand Change[2]
			(lb ai/A)	(%)
1	Escort + NIS	Late Bud	0.0375	-4.51 a[3]
2	Velpar + NIS	Late Bud	2	-78.03 b
3	Atrazine + oil	Late Bud	4	-77.76 b
4	Arsenal	Late Bud	1	-66.96 b
5	XRM 3972 + NIS	Late Bud	0.2	-71.83 b
6	Crossbow + NIS	Late Bud	1	-71.91 b
7	Escort +	Late Bud	0.0375	-69.00 b
	Roundup + NIS		1	
8	Garlon +	Late Bud	0.67	-46.55 ab
	Banvel 720 + NIS		0.33	
9	Mechanically-cut	Late Bud	---	-33.98 ab
10	Control	--------	---	-3.73 a

1 - Treatment timing: June 10, 1986
2 - % Stand Change from the previous year =
((stand count 1986 - stand ct 1987)/ stand ct 1986) * 100
3 - Means followed by the same letter are not significantly different using Duncan's Multiple Range Test at the 0.05 level
NIS = "WK" non-ionic surfactant @ 0.25%
Oil = crop oil concentrate @ 2 qts/A

EXPERIMENT 3

Objective

To screen several herbicide treatments for their effect on crownvetch.

Materials and Methods

Several herbicide treatments were applied to a pure stand of crownvetch in Danville, Montour County to evaluate the tolerance of the crownvetch to the herbicides. The applications were made with a hand held boom in the equivalent of 12 gallons of water per acre. Ratings were taken monthly over the 1986 and 1987 season to visually estimate percent crownvetch cover and canopy height. The treatments, rate, and timing are listed in Table 4. For specific application dates refer to the footnote in Table 5.

Table 4. Treatments, timings, and rates used in Experiment 3.

Treatment		Timing	Rate	Treatment		Timing	Rate
1	Atrazine	Dormant	4	11	Crossbow	Late Spring	1
2	Velpar	Dormant	2	12	XRM 3972	Late Spring	0.2
3	Arsenal	Dormant	1	13	Oust	Late Spring	0.2
4	Velpar	Late Spring	2	14	Garlon	Late Spring	0.67
5	Arsenal	Late Spring	1		+ Banvel 720		0.33
6	Atrazine	Late Spring	4	15	Atrazine	Summer	4
7	Escort	Late Spring	0.0375	16	Velpar	Summer	2
8	Escort	Late Spring	0.0375+1	17	Arsenal	Summer	1
	+ Roundup			18	Dyrene	Late Spring	3
9	Escort	Late Spring	0.0375+0.67	19	Dyrene	Summer	6
	+ Garlon 4			20	Untreated Check		- -
10	Garlon 4	Late Spring	0.67+7.4				
	+ Weedone 170						

Results and Discussion

When controlling unwanted weeds in a crownvetch groundcover along roadsides, a minimum of damage to the crownvetch plant is desired. The optimum herbicide treatment should display low levels of foliar injury to crownvetch. If the vegetation canopy is reduced to a low density, the opportunity for problem weed invasion will exist.

Ratings for crownvetch canopy height and percent cover were tabulated and the means analyzed using Duncan's New Multiple Range Test (Table 5). On June 1, the first rating date of 1987, the crownvetch displayed no effects from many treatments applied the previous year, although results varied for both height and percent cover within some treatments examined. By July 1, all treatments except Oust (T 13) and Arsenal (T 17) were measured to be significantly the same. By September 1, only treatment 17 still demonstrated a lower canopy cover .

Survival of the crownvetch alone is not enough to deem an herbicide desirable. The treatment must also be effective in controlling the problem weed, Canada thistle. Using the results from the 1986 and 1987 screening trials on crownvetch and the stand count results on Canada thistle, three treatments to fulfilled these requirements. These were Velpar at 2.0 lb ai/A, atrazine at 4.0 lb ai/A, and XRM 3972 (clopyralid) at 0.2 lb ai/A. Application timing was late spring at the early to late bud stage of Canada thistle. Crownvetch had a high degree of tolerance to these treatments in the 1986 season and were rated the same as untreated crownvetch throughout the 1987 season.

Table 5 Sensitivity of Brush and Non-Cropland Herbicides on Crownvetch - 1987
Interstate 80 - Exit 33 W; Danville, PA

	Treatment			Height					Cover				
	Herbicide	Timing [1]	Rate	6/01	7/01	7/30	8/31	9/30	6/01	7/01	7/30	8/31	9/30
			(lb ai/A)	(cm)	(cm)	(cm)	(cm)	(cm)	(%)	(%)	(%)	(%)	(%)
1	Atrazine	Dormant	4	52 ab [2]	46 a	43 a	37 a	29 ab	87 a	78 a	80 ab	79 a	89 a
2	Velpar	Dormant	2	35 c-f	37 ab	45 a	37 a	33 ab	59 a-d	66 a	56 b	50 b	82 a
3	Arsenal	Dormant	1	41 b-e	37 ab	35 ab	29 ab	24 ab	70 a-c	58 a	74 ab	74 ab	89 a
4	Velpar[3]	Late Spring	2	57 a	49 a	47 a	38 a	31 ab	88 a	78 a	77 ab	69 ab	78 a
5	Arsenal	Late Spring	1	26 fg	36 ab	35 ab	31 ab	29 ab	36 de	54 a	59 ab	67 ab	88 a
6	Atrazine[4]	Late Spring	4	47 a-d	39 ab	38 ab	34 a	28 ab	86 a	70 a	83 ab	78 a	79 a
7	Escort[3]	Late Spring	0.0375	33 d-g	43 a	42 a	34 a	29 ab	43 c-e	71 a	72 ab	72 ab	84 a
8	Escort + Roundup[3]	Late Spring	0.0375+1	35 c-g	36 ab	34 ab	29 ab	24 ab	61 a-d	67 a	73 ab	71 ab	82 a
9	Escort + Garlon 4[3]	Late Spring	0.0375+0.67	32 e-g	39 ab	40 a	35 a	32 ab	52 b-e	69 a	74 ab	68 ab	84 a
10	Garlon 4 + Weedone 170[3]	Late Spring	0.67+7.4	40 b-f	39 ab	44 a	35 a	29 ab	61 a-d	73 a	74 ab	66 ab	80 a
11	Crossbow[3]	Late Spring	1	44 a-e	43 a	44 a	36 a	30 ab	68 a-d	72 a	71 ab	74 ab	86 a
12	XRM 3972	Late Spring	0.2	46 a-e	39 ab	42 a	29 ab	28 ab	86 a	72 a	72 ab	67 ab	85 a
13	Oust[3]	Late Spring	0.2	21 gh	22 bc	21 bc	22 ab	24 ab	22 e-g	19 b	24 c	61 ab	81 a
14	Garlon 4 + Banvel 720[3]	Late Spring	0.67+0.33	49 a-c	48 a	41 a	28 ab	31 ab	78 ab	71 a	66 ab	61 ab	84 a
15	Atrazine[4]	Summer	4	47 a-d	48 a	46 a	39 a	39 a	82 ab	76 a	71 ab	66 ab	78 a
16	Velpar[3]	Summer	2	55 ab	39 ab	34 ab	26 ab	24 ab	88 a	77 a	78 ab	77 ab	82 a
17	Arsenal	Summer	1	10 h	15 cd	17 c	16 b	17 b	9 fg	21 b	29 c	27 c	60 b
18	Dyrene[3]	Late Spring[5]	3	--	38 ab	37 ab	30 ab	28 ab	--	80 a	68 ab	59 ab	77 a
19	Dyrene[3]	Summer[5]	6	--	--	38 ab	32 ab	29 ab	--	--	84 a	74 ab	77 a
20	Untreated Check		--	48 a-d	43 a	45 a	34 a	31 ab	82 ab	72 a	82 ab	71 a	77 a

1 - 1986 Treatment timing: Dormant - March 25 (trt. 1,2), April 7 (trt. 3); Late spring - May 29 (trt. 4,5,6), June 12 (trt. 7,9,11,12,14,15), June 17 (trt. 8,10); Summer - July 30.

2 - Column means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

3 - Includes non-ionic surfactant @ 0.25%.

4 - Includes crop oil concentrate @ 2 quarts/Acre.

5 - 1987 Treatment timing: Late spring - June 6 ; Summer - July 30.

EXPERIMENT 4

Objective

To determine proper timing for effective herbicide application in the same season by measuring total nonstructural carbohydrate levels (TNC) in Canada thistle that has been treated with herbicides.

Materials and Methods

The site for Experiment #4 was established on Interstate 80 between the Lamar and Bellefonte. The herbicide treatments for Canada thistle, Velpar, atrazine, and XRM 3972 (clopyralid), were selected using the results from experiments one, two, and three. Plot size was 8 feet by 60 feet and arranged in a randomized complete block design. Root samples of Canada thistle were collected once on October 15 of 1986 and at two week intervals from April 16 through September 2 of 1987. All root samples were taken during the same time period of the day for each sampling date, washed thoroughly with water to remove all soil, and oven dried at 70 degrees Centigrade to denature respiratory enzymes and thereby reduce respiratory losses. All samples were ground to a 40 mesh size fineness. A modified Weinmann method, which is an enzymatic digestion with acid hydrolysis of polysaccharides, was used for removing TNC. The amount of TNC was then determined colorimetrically using the Technicon auto-analyzer.

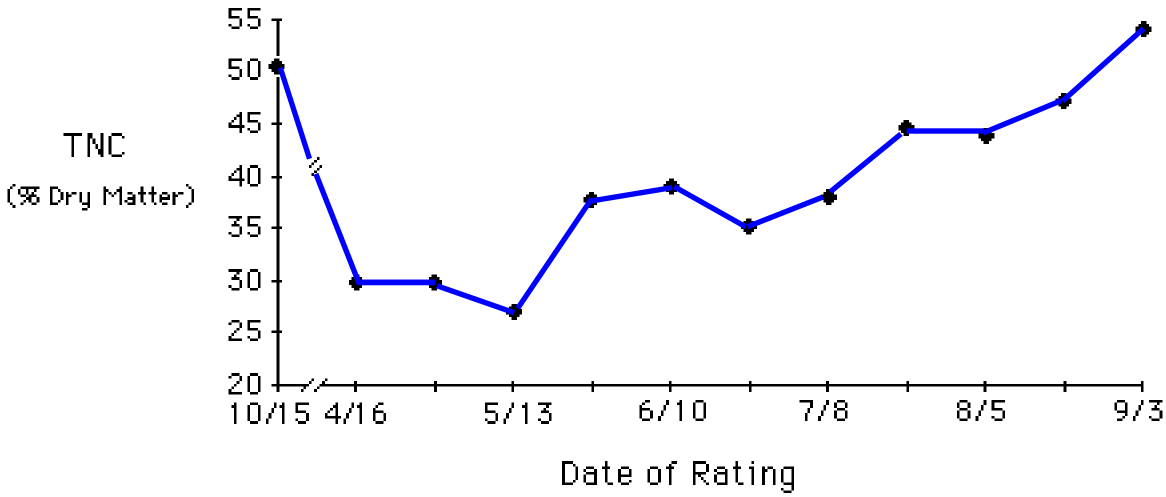
Results and Discussion:

One single application of herbicides tested on Canada thistle did not give complete control as regrowth occurred within the same season. Researchers studying Canada thistle believe regrowth after treatment is from rootstocks of treated plants. However, by August, no regrowth could be found from the roots of treated plants. Aboveground regrowth seen in all three treatments was from younger developing roots. These roots displayed no visual effects of the herbicide treatment and are now thought to be from untreated plants. The roots of the treated plants were dying and decaying at different rates after treatment, eventually leaving just the untreated, developing roots. Therefore, most root samples contained a degree of both types of roots. Since the developing roots had a high level of TNC, the data generated from these samples contained a significant amount of variation. Unfortunately, statistical analysis of this data is unreliable. It is concluded the measurement of TNC to indicate susceptibility of the treated thistle stand to control is invalid unless the treated and untreated roots can be separated. The plants showing growth after treatment may have been from rootstocks separated earlier in the season from the parent plant or from root sections that had not produced any aboveground growth when the treatment was applied.

The data (figure 1) for the untreated check plot suggests that the point where Canada thistle is most susceptible to control is not at the late bud stage, but earlier in the season. This study indicates the low point for of TNC is in late

April to mid-May. Previous research states that this low point can vary from year to year. Although the thistle stand appears to be susceptible to control early in the season, it is important that the total spring flush of aboveground growth has emerged to allow sufficient herbicide contact with the foliage.

Figure 1. TNC Change Over Time 1986-87



Summary

As the results of experiment 1 and 2 show, a number of herbicide treatments produced a high degree of control to Canada thistle. However, not only does a desirable herbicide treatment need to control Canada thistle, but as stated in experiment 3, the crownvetch must have a high level of tolerance to the treatment. Only by combining the Canada thistle results of experiment 1 and 2, and the crownvetch tolerance results of experiments 2 and 3, can the best treatments be determined. Atrazine at 4.0 lbs ai/A, Velpar at 2.0 lbs ai/A, and XRM 3972 (clopyralid) at 0.2 lbs ai/A applied at the the early to late bud stage of Canada thistle fulfilled these requirements.

The results from experiment 4 indicated the statement made by other researchers that the low point of TNC of Canada thistle roots is at the bud stage may be oversimplified. This data suggested the thistles expend a significant amount of TNC to produce the initial underground shoot growth that occurs in the early spring. On April 16 , when the first sampling of 1987 was taken and the thistle stand had reached a height of 1 to 2 inches, the TNC levels were already statistically at the low point in their lifecycle. However, since not all shoots had emerged from the soil at that point in time, a foliar herbicide treatment would be premature.

By early June, at the late bud to early flowering stage, the thistles had already replenished their TNC root reserves equal to the reserves measured the previous fall. From this experiment, the most susceptible time for a post herbicide treatment was found to be in early to mid May when the thistles were starting to bud. This is when the stand had fully produced its spring flush of shoot growth and the TNC levels were still at their lowest points. However, as previous work shows, this low point will vary slightly from year to year, therefore an application in late May into early June may be as effective in some years.

BRUSH CONTROL STUDY

The brush control research for 1987 consisted of experiments with Basal Bark, Fall Foliar, and Dormant Stem applications.

All herbicides used in the brush control study are listed in Table 1. This table can be used to reference the common names, and formulation of a particular product. For ease of reading, all herbicides will be referred to by their product name.

Table 1. Herbicide names, formulation, and manufacturer used for all the experiments.

Product Name	Common Name	Formulation	Manufacturer
Access	Triclopyr + Picloram	2#/Gallon 1#/Gallon	Dow USA Inc.
Banvel 520	Dicamba + 2,4-D	1#/Gallon 1#/Gallon Ester	Sandoz Crop Protection Co.
Banvel 720	Dicamba + 2,4-D	1#/Gallon 1.9#/Gallon Amine	Sandoz Crop Protection Co.
Chopper	Imazapyr		American Cyanamid Co.
Escort	Metsulfuron methyl	60 DF	E.I. Dupont De Nemours Co.
Garlon 4	Triclopyr	4#/Gallon Ester	Dow USA Inc.
Garlon 3A	Triclopyr	3#/Gallon Amine	Dow USA Inc.
Krenite	Fosamine ammonium	4#/Gallon	E.I Dupont De Nemours Co.
Roundup	Glyphosate	4#/Gallon	Monsanto Co.

Diluents & Surfactants	Manufacturer
Basal Oil	Arborchem Products
Clean Cut + Pine	Arborchem Products
Cidekick	JLB International
Booster + E	Agway Inc.

BASAL BARK APPLICATIONS

Three basal bark experiments were conducted in 1987. The first compared the efficacy of two herbicides applied at multiple rates in two different diluents. The second examined the effect of volume of application on the efficacy of one treatment solution on the control of two species of brush. The third experiment investigated the movement of the herbicides in treated plants.

Experiment 1

Objective

To examine the efficacy of Garlon 4 at 5% & 20% (v/v), using either diesel fuel or basal oil as the diluent and Chopper at 6.25% (v/v) with basal oil as the diluent. The treatments were applied to green ash (Fraxinus pennsylvanica Marsh.), black birch (Betula lenta L.) and red maple (Acer rubrum L.).

Materials and Methods

The five treatments are listed below:

Product	Rate v/v	Diluent
Garlon	5%	Basal Oil
Garlon	20%	Basal Oil
Garlon	5%	Diesel Fuel
Garlon	20%	Diesel Fuel
Chopper	6.25%	Basal Oil

The application was made in March 1987 while the trees were dormant, using a B&G Extenda-Ban Valve with an 18" extension and a Spraying Systems #5500 Cone Jet Nozzle with a Y-2 tip adjusted to produce a fine mist. The treatment was applied to the bottom 6" to 12", of the stems which ranged from 0.5" to 6" in caliper for each species. An average of 40 stems per treatment were utilized for ash, 30 stems per treatment for maple, and 20 stems per treatment for birch. During application to the ash and birch, the air temperature was 55º F and the soil temperature at a 6" depth was 30º F. During application to maple the air temperature was 14º F and the soil temperature was 28º F. The trees were rated for injury approximately 13 weeks after application on 6/9/87 and again approximately 22 weeks after application on 8/19/87. Injury was rated on a scale of 0-5 with 0 being no effect, and 5 being dead. The ratings of 1-4 represented increasing degrees of injury.

Results and Discussion

Injury ratings for all treatments were higher on 8/19/87 than 6/9/87 (Table 2). Low rates of herbicides applied as basal bark applications may cause an eventual decline of all treated stems over time. If the lower dosage will eventually produce results similar to those obtained with the higher dose, substantial material savings could be realized while still obtaining adequate control. The vegetation manager must determine the best approach for his program. It is critical to evaluate this experiment during the 1988 season to determine the final injury assessment. Plants that received an injury rating of "4" on 8/19/87 are not expected to survive the 1988 season.

No dramatic differences in efficacy resulted between the use of diesel fuel or basal oil as diluent in the treatments containing Garlon with the exception of black birch, in which 5% Garlon in basal oil killed 28% of treated stems while 5% Garlon in diesel fuel killed 58% of treated stems by 8/19/87. The reason for the difference between these two treatments is not known.

On 6/9/87, Chopper provided the best control of ash when compared to the other treatments and by 8/19/87 had killed 94% of the treated stems. Garlon at 20% killed over 90% of treated stems by 8/19/87 while Garlon at 5% killed approximately 65% of the stems by the same date.

Red maple was the most sensitive to all the herbicide treatments. Garlon at 20% in basal oil, and Garlon (5% & 20%) in diesel fuel killed all treated stems by 6/9/87. At the same date Garlon at 5% in basal oil killed 81% while Chopper only killed 17%. By 8/19/87, Chopper had killed 92%, and 5% Garlon in Basal Oil had killed 88%.

All herbicide treatments were less effective on black birch than on ash and maple. Injury symptoms were noted on birch on 6/9/87, but no trees were killed by any treatment by that date. On 8/19/87, the Chopper treated plants continued to display only marginal activity and no trees were killed or seriously injured. Garlon at 20% provided the most activity on the birch, killing 69% (basal oil) and 78% (diesel) of the stems treated. Garlon at 5% killed 28% (Basal Oil) and 55% (diesel fuel) of the birch.

Table 2. Injury ratings of trees treated with basal bark applications of triclopyr at 5% or 20% (v/v) in Basal Oil[1] or diesel fuel; or imazapyr at 6.25% (v/v) in Basal Oil. All treatments were applied in March, 1987.

Control Rating[2]	Rated 6/9/87 Percentage of Stems in Each Rating Group					Rated 8/19/87 Percentage of Stems in Each Rating Group				
	Triclo 5% Basal Oil	Triclo 20% Basal Oil	Triclo 5% Diesel	Triclo 20% Diesel	Imaza 6.25% Basal Oil	Triclo 5% Basal Oil	Triclo 20% Basal Oil	Triclo 5% Diesel	Triclo 20% Diesel	Imaza 6.25% Basal Oil
White Ash - Average 40 stems per treatment										
0	0	0	0	0	0	0	0	0	0	0
1	0	0	5	0	0	0	0	0	0	0
2	16	2	8	0	3	0	0	2	0	0
3	49	49	60	35	0	5	0	5	0	0
4	30	38	27	65	56	28	7	30	2	6
5	5	11	0	0	41	67	93	63	98	94
Black Birch - Average 20 stems per treatment										
0	0	0	0	0	0	0	0	0	0	0
1	12	0	9	0	65	0	0	0	0	10
2	24	13	5	6	29	6	0	0	0	55
3	64	81	77	75	1	28	5	9	0	35
4	0	6	9	19	0	38	26	36	22	0
5	0	0	0	0	0	28	69	55	78	0
Red Maple - Average 30 stems per treatment										
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	8	0	0	0	0	6	0	0	0	0
4	11	0	0	0	83	6	0	0	0	8
5	81	100	100	100	17	88	100	100	100	92

1) Basal Oil is a highly refined petroleum product produced by Arborchem Products Co.
2) Control Ratings 0 = No Effects, 5 = Dead

Experiment 2

Objective

To evaluate the effects of controlled amounts of Garlon 4 applied in Basal Oil to the stems of green ash and black birch.

Materials and Methods

Approximately 15 stems of green ash and black birch were selected to receive each of three treatments. The circumference of the stems was measured at 18 inches above the ground. The treatments consisted of applying 0.5, 1.0, or 2.0 ml/inch circumference of Garlon 4 at 20% in Basal Oil. A hypodermic needle and syringe were used to apply the chemical solution to the bark in precise amounts without drift. Treatments were applied on March 10, 1987. The air and soil temperatures were 55 º F and 30 º F, respectively. The treatments were evaluated on 6/9/87 and 8/19/87, using the same rating system utilized in experiment 1.

Results and Discussion

A summary of the ratings is presented in Table 3. The 1.0 ml/inch circumference rate provided control that was better than the 0.5 ml rate and equal to the 2.0 ml rate. The level of control increased between the first and second rating periods. It is not yet known what the ultimate level of control will be. Control will have to be rated again in the summer of 1988.

Table 3. Control provided by varying amounts of 20% Garlon in Basal Oil applied on these stems (of green ash and black birch).

	Percentage of Stems in Each Rating Group							
	Rated 6/9/87			Rated 8/19/87				
Control Rating [1]	.5 ml/ inch Circum.	1.0 ml/ inch Circum	2.0 ml/ inch Circum	.5 ml/ inch Circum.	1.0 ml/ inch Circum	2.0 ml/ inch Circum		
Green Ash - Average 15 stems per treatment								
0	0	0	0	0	0	0		
1	35	0	0	0	0	0		
2	12	31	0	35	0	0		3
35	56	93	41	31	0			
4	18	13	7	6	19	7		
5	0	0	0	18	50	93		
Black Birch - Average 15 stems per treatment								
0	0	0	0	0	0	0		
1	0	0	0	0	0	0		
2	0	0	0	0	0	0		
3	79	50	41	43	0	12		4
21	36	53	50	50	41		5	0
14	6	7	50	47				

Experiment 3

Objective

To determine the degree of translocation within the plant of Garlon 4 and Access applied to the stems of red maple and sassafras.

Materials and Methods

Approximately 15 stems per treatment of red maple and sassafras were selected for study. Red maple was chosen to represent an easily controlled species and sassafras a prolific suckering species. The chemicals used were Garlon 4 at 20% and Access at 20% (equivalent to Garlon at 10% and Tordon at 5%) in Basal Oil. The application was made on April 30, 1987, using the same equipment described in Experiment 1. Prior to application, a band of rope caulking was applied around the base of the stems approximately 4-6" above the ground line. The herbicide solution was applied six inches above the caulk and allowed to run down the stem to the caulk. An attempt was made to limit puddling of the chemical in the caulk ring. The caulk established a line past which very little of the herbicide moved. Several of the maples chosen for treatment were multi-stemmed or forked close to the base of the plant. In these situations, only one of the stems or forks was treated. The untreated stem will be monitored for treatment effects to determine movement of the herbicide within the plant system. If the herbicide moves into the roots and kills them, as some people suggest, both stems on a forked tree should die. If the treated stem dies and the other survives, the chemical probably killed by a girdling effect. During the 1988 season, the trees can be cut down and dissected to help determine herbicide movement within the tree. The treated sassafras were inadvertently cut down during the season and were eliminated from the study.

The maple was evaluated on 8/9/87 using the same rating system utilized in experiments 1 and 2.

Results and Discussion

Preliminary results are presented in Table 4. The Garlon provided slightly better control than the Access, but final results will not be known until the summer of 1988. The Garlon did not provide quite as good control as the 20% Garlon treatment in Experiment 1, probably because up to 12" of the stems were treated in that study versus 6" in this study.

Table 4. Control of red maple provided by basal bark applications of 20% Garlon and 20% Access.

CONTROL RATING	Percentage of Stems in Each Rating Group Rated 8/19/87 Garlon (20%)	Access (20%)[1]
Red Maple - Average 15 stems per treatment		
0	0	0
1	0	0
2	0	7
3	7	21
4	21.5	36
5	71.5	36

1- Access at 20% is equivalent to Garlon (10%) plus Tordon (5%)

FALL FOLIAR APPLICATIONS

Objective

An experiment was conducted to examine the efficacy of Krenite S applied at differing rates and in combination with other herbicides.

Materials and Methods

The treatments were applied with a Radiarc spray system in the equivalent of 75 gallons of water per acre on September 1, 1986. Boxelder maple (Acer negundo L.), silver maple (Acer saccharinum L.), black locust (Robinia pseudoacacia L.), ash spp. (Fraxinus spp.), crabapple spp. (Malus spp.), multiflora rose (Rosa multiflora Thunb.), butternut (Juglans cinerea L.), and sumac spp. (Rhus spp.) were growing within the plot areas. Not every species was present in each plot, yet a significant number of these species was present within the study area. The treatments are listed in Table 5.

Table 5. Treatments and rates used in fall foliar experiment.

Product	Rate
1. Krenite	1.5%
2. Krenite +	1.5%
Escort	1 oz./100 gal.
3. Krenite +	1.5%
Garlon	0.5%
4. Krenite +	1.5%
Roundup	1%
5. Krenite +	1.5%
Banvel 720	0.5%
6. Krenite +	1%
Garlon	0.5%
7. Krenite +	1%
Roundup	1%
8. Krenite +	1%
Banvel 720	0.5%

The treated areas were rated in June of 1987, approximately nine months after treatment. Each plant species was identified within each plot and rated for injury. The rating scale is listed below:

Rating Scale

1 - No injury
2 - Slight injury to contacted branches
3 - Contacted branches are severely stunted and chlorotic, recovery expected
4 - Some dead tips on contacted branches with some resprouting
5 - All or most of contacted branches are dead
6 - Some branches not contacted by the herbicide are severely injured or dead
7 - Entire plant is dead

Results and Discussion:

Krenite at 1.5% in combination with Escort, Roundup, or Garlon, provided better control of apple, boxelder, butternut, and black locust, than did Krenite 1.5% applied alone (Table 6). Krenite at 1.5% plus Escort offered good control of all contacted portions of apple, ash, and black locust, while contacted foliage of boxelder was chlorotic and stunted but is expected to recover and continue growth. Krenite at 1.5% plus Garlon showed good control of ash, buckeye, and maple with some resprouting on apple and multiflora rose. Krenite at 1.5% plus Roundup demonstrated good control on contacted foliage of apple, black locust, and multiflora rose, with some minor resprouting of butternut. Krenite 1.5% plus Banvel 720 provided good control on contacted foliage of locust, butternut, and multiflora rose, with only limited regrowth of multiflora rose and locust while vigorous regrowth occurred from the trunk of butternut.

Krenite at 1% with Garlon, Roundup, or Banvel 720, provided better control than when Krenite at 1.5% was applied alone. Krenite 1% plus Garlon controlled contacted parts of apple, boxelder, black locust, and multiflora rose, with resprouting occurring from major branches of boxelder and multiflora rose. Krenite at 1% plus Roundup showed excellent control of apple, ash, boxelder, black locust, silver maple, and multiflora rose with regrowth occurring from major branches on boxelder while ash foliage was displaying severe distortions 5 feet from the treated area. Krenite at 1% plus Banvel 720 controlled butternut, while resprouting was present on apple and maple.

Krenite applied alone at 1.5% in 75 gallons of water per acre (gpa) did not provide adequate control of some of the species treated. One way to improve control is to lower the volume of spray solution applied without decreasing the amount of chemical applied per treated acre. This study also showed that the amount of Krenite applied could be reduced to 1% in 75 gpa if combined with Garlon 4, Roundup, or Banvel 720.

Table 6. Control of roadside brush treated on Sept. 1, 1986 with two rates of Krenite alone or in combination with Escort, Garlon, Roundup, or Banvel 720. Treatments were rated on June,1987.

PRODUCT	RATE	CONTROL RATING Apple	Ash	Buck-eye	Box-elder	Butter-nut	Black Locust	Silver Maple	Mult. Rose
Krenite S	1.5%	3			3	4	5		3
Krenite S + Escort	1.5% 1oz./100gal.	5	5		3		5		
Krenite S + Garlon 4	1.5% 0.5%	4	5	5				5	4
Krenite S + Roundup	1.5% 1.0%	5				6	5		5
Krenite S + Banvel 720	1.5% 0.5%					5	5		5
Krenite S + Garlon 4	1.0% 0.5%	5			4		5		4

Krenite S + Roundup	1.0% 1.0%	5	6		4		5	5	5
Krenite S + Banvel 720	1.0% 0.5%	4				5		4	

DORMANT STEM APPLICATIONS

Experiment 1

Objectives

1. To determine the effectiveness of 1% and 5% solutions of Garlon 4 plus a penetrant applied to dormant stems in March:
2. To compare the effectiveness of three penetrants used to improve the control provided by Garlon applied to dormant stems; and
3. To compare the effectiveness of Garlon 4 at 1% applied alone or in combination with Roundup at 1% or Escort at 1 oz./100 gallons of water.

Materials and Methods

The treatments were:

Product	Rate	Penetrant (2%)
Garlon 4	1%	Cidekick
Garlon 4	5%	Cidekick
Garlon 4	1%	Clean Cut + Pine
Garlon 4	5%	Clean Cut + Pine
Garlon 4	1%	Booster Plus E
Garlon 4	5%	Booster Plus E
Garlon 4 +	1%	Booster Plus E
Escort	1oz./100 gal. water	
Garlon 4 +	1%	Booster Plus E
Roundup	1 %	

All treatments were applied in March 1986 in Perry Co. Pa. with a Radiarc spraying system in the equivalent of 80 gallons of water per acre. Boxelder maple (Acer negundo L.), red maple (Acer rubrum L.), ash spp. (Fraxinus spp.), hickory spp. (Carya spp.), oak spp. (Quercus spp.), privet spp.(Ligustrum spp.) redbud (Cercis canadensis L.), hackberry (Celtis occidentalis L.), cherry spp.(Prunus spp.), elm spp.(Ulmus spp.), mulberry (Morus alba L.), and sumac spp.(Rhus spp.), viburnum spp.(viburnum spp), ostyra spp. (Ostrya spp), grew within the plot areas. The understory consisted of perennial grasses and herbaceous weeds.

Results and Discussion

Garlon at 5% provided excellent results regardless of crop oil treatment (Table 7). All treatments of Garlon at 1% provided less control. When applied with 1% Garlon , the Cidekick + Garlon provided less control than the other crop oil treatments. Brush treated with Garlon at 1% resprouted and the long term control was unacceptable. Resprouting was noted on stems greater than 1" in diameter of cherry, maple, ash, ostrya, and redbud. The addition of Escort or Roundup to Garlon at 1% did not increase the level of control over Garlon (1%) alone. Garlon at 5% controlled almost all brush contacted with the exception of some minor resprouting of maple and marginal control of cherry. Some treatments of Garlon at 5% were effective in controlling stems well beyond the treated area. All treatments controlled the understory plants with control increasing as the rate of Garlon increased.

Table 7. Control ratings of roadside brush receiving dormant stem treatments in March, 1986. All treatments were applied in the equivalent of 80 gallons of water per acre with emulsifiable crop oils applied at 2% by volume.

Chemical	Rate	Emulsifiable Crop Oil	Percent Control
Garlon 4	1%	Cidekick	50
Garlon 4	1 %	Clean Cut + Pine	90
Garlon 4	1 %	Booster Plus E	80
Garlon 4	5 %	Cidekick	95
Garlon 4	5 %	Clean Cut + Pine	99
Garlon 4	5 %	Booster Plus E	99
Garlon 4 +	1 %	Booster Plus E	50
Escort	1oz./100 gal. water		
Garlon 4 +	1 %	Booster Plus E	75
Roundup	1 %		

Experiment 2

Objectives

1. To determine the effects of Garlon 4 at 1% or 3%, Banvel 520, or a combination of Garlon and Banvel 520 applied to brush during the dormant season; and
2. To determine the effects of time of application of the treatments.

Materials and Methods

Plots were established along a roadside in Chester County PA. Boxelder maple (Acer negundo L.), ash spp. (Fraxinus spp.), butternut (Juglans cinerea L.), hickory spp. (Carya spp.), oak spp. (Quercus spp), hackberry (Celtis occidentalis L.), cherry spp.(Prunus spp.), elm spp.(Ulmus spp.), mulberry (Morus alba L.), grew within the study areas. The understory consisted of perennial grasses, herbaceous weeds, poison ivy (Toxicodendron radicans L.), and periwinkle (Vinca minor L.). Roadside brush was treated with Garlon at two rates, Banvel 520, or a combination of Garlon and Banvel 520, at two times during the dormant season. The treatments were applied on December 16, 1986 and March 12, 1987 with the same treatments used in experiment 1. Control was rated on September 27, 1987.

Results and Discussion

None of the treatments applied in December provided adequate brush control for roadsides (Table 8). Garlon at 1% applied in March provided good control of boxelder, butternut, and hickory. All contacted stem tips were killed, but some resprouting occurred on the stem below the branch tip. Garlon at 1.5% + Banvel 520, provided adequate control of hackberry and poison ivy and marginal control of oak, but was not effective on elm or hickory. Garlon at 3% provided excellent control of ash, boxelder, hackberry, mulberry, cherry, and elm, with some minor resprouting noted on ash. Treatments including Garlon killed the broadleaf understory vegetation. The amount of understory vegetation controlled increased as the rate of Garlon increased. Banvel 520 provided little or no control of roadside brush when applied to dormant stems in this manner.

Table 8. Control ratings of roadside brush treated with Garlon 4 and Banvel 520, alone or in combination, in December 1986, and March 1987. All treatments were applied in the equivalent of 75 gallons of water per acre and contained 2% by volume of the emulsifiable crop oil Clean Cut + Pine. Treatments were rated on September 27,1987.

CHEMICAL	RATE	APPLICATION TIME & CONTROL RATING 1/ DECEMBER '86	MARCH '87
Garlon 4	1%	1	4
Garlon 4	3%	2	4.75
Garlon 4 + Banvel 520	1.5% .75%	2	3.5
Banvel 520	1.5%	1	1.5

1/ - Control Rating: 0 = No Effects, 5 = Dead