# *BROADLEAF WEED CONTROL WITH POSTEMERGENCE APPLICATIONS OF CGA-152005*

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## *ABSTRACT*

*CGA-152005 was evaluated as a postemergence herbicide for corn (Zea mays L.) in replicated field trials at locations in Michigan, Maryland, New York, Pennsylvania, and Ohio from 1990-1992. Weeds present were Canada thistle [Cirsium arvense (L.)Scop.] , velvetleaf (Abutilon theophrasti Medik.), hedge bindweed [Calystegia sepium (L.)R.Br.], redroot pigweed (Amaranthus retroflexus L.), common lambsquarters (Chenopodium album L.), morningglories (Ipomoea spp.), common ragweed (Ambrosia artemisiifolia L.), common cocklebur (Xanthium stramonium L.)and giant ragweed (Ambrosia trifida L.). In all cases, CGA-152005 was applied with either a non-ionic surfactant or crop oil concentrate.*

*CGA-152005 applied at 0.14-0.29 OZ AI/A was extremely effective on redroot pigweed, common ragweed, giant ragweed and common cocklebur. Rates of 0.29-0.43 OZ AI/A resulted in very good to excellent control of hedge bindweed, velvetleaf, and morningglories. Canada thistle control was good to very good where CGA-152005 was applied at 0.29-0.43 OZ AI/A. Common lambsquarters control was excellent at 0.29 OZ AI/A in many cases but, under dry conditions or heavy populations, addition of dicamba at 0.125-0.25 pints/acre was needed to obtain a rapid and thorough knockdown. CGA-152005 was equally effective on both triazine resistant and susceptible biotypes of lambsquarters, pigweed, and velvetleaf.*

*CGA-152005 is an excellent new posteemergence compound for the control of a wide range of broadleaf weeds in corn and offers an alternative to those herbicides currently available.*

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# FIRST YEAR EXPERIENCES WITH MON-12000 IN MARYLAND

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## ABSTRACT

MON-12000 is a new sulfonylurea herbicide under development by the Monsanto Company for broadleaf weed control in corn (Zea mays L.). This product is being evaluated preemergence and postemergence. Preemergence applications include a safener (MON-13900) being added to MON-12000. This mixture is being tested under the proposed trade name of Battalion. Postemergence applications of MON-12000 do not include the addition of a safener. This product is being tested under the proposed trade name of Permit. Both formulations of MON-12000 were field tested in 1992 under Maryland conditions.

Preemergence applications of MON-12000 provided good (80-100%) season-long control of triazine-resistant (TR) smooth pigweed (Amaranthus hybridus L.) and TR common lambsquarters (Chenopodium album L.). However, early-season corn injury was evident. Injury was generally expressed as shortened, chlorotic corn plants. Visual injury ratings were made on a scale of 0% (no injury) to 100% (complete plant dessication). At two locations, visual injury ratings of 20 to 30% were obtained, when evaluated approximately 4 to 6 weeks after application. Yet, by mid to late season, the crop recovered and no injury was evident. MON-12000 was evaluated at 0.065, 0.075, and 0.094 lb ai/A as a preemergence treatment. These rates provided poor (<60%) annual grass control. Yet, good control of TR smooth pigweed and TR common lambsquarters was obtained with all three rates.

Postemergence applications of MON-12000 were evaluated on a variety of weed species including TR smooth pigweed, TR common lambsquarters, susceptible (TS) common lambsquarters, giant ragweed (Ambrosia trifida L.), and burcucumber (Sicyos angulatas L.). Rates evaluated include the following: 0.016, 0.032, and 0.064 lb ai/A. The 0.032 lb ai/A rate was targeted for most applications. A nonionic surfactant at 0.25% v/v was included with all applications.

Postemergence applications of MON-12000 provided good control of TR smooth pigweed at all three rates. In contrast, poor control of TR and TS common lambsquarters was obtained at 0.032 and 0.064 lb ai/A. Poor control of burcucumber was also obtained at the 0.032 lb ai/A rate, while good control of giant ragweed was obtained at the same rate. With all postemergence applications, little to no injury was observed.

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# ACTIVITY OF NICOSULFURON AND PRIMISULFURON ON CANADA THISTLE

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## ABSTRACT

Field studies were conducted in 1991 and 1992 at Washington County, Maryland to evaluate Canada thistle [Circium arvense (L.) Scop.] control in no-tillage corn (Zea mays 'Pioneer 3352'). Corn was planted in mid-May and all study areas were treated with 0.5 lbs/A paraquat, 2.0 lbs/A metolachlor, 1.6 lbs/A atrazine, and 0.25% (by vol) X-77 immediately following planting. Postemergence applications were made when Canada thistle was 5 to 7 inches high and corn was 8 inches high. The experiments were arranged with a randomized complete block design with three replications per treatment. Plots were two treated rows by 35 feet. All treatments containing nicosulfuron or primisulfuron included 0.25% X-77. Postemergence applications of 0.031 lbs/A nicosulfuron, 0.024, and 0.048 lbs/A primisulfuron provided 64, 73, and 73% Canada thistle control, respectively, 8 weeks after treatment (WAT). Canada thistle control following applications of tank mixture of nicosulfuron with 0.25 (75%) or 0.5 lbs/A 2,4-D (82%), or 0.13 (86%) or 0.25 lbs/A dicamba (87%) increased compared to that obtained with nicosulfuron, 0.5 lbs/A 2,4-D (56%), or 0.25 lbs/A dicamba (54%) applied alone. Canada thistle control following tank mixture applications of 0.048 lbs/A primisulfuron with 0.25 lbs/A 2,4-D (85%) and 0.25 lbs/A dicamba (85%) was greater than that obtained with the herbicides applied alone. In a greenhouse study, 0.031 lbs/A nicosulfuron produced 77% injury to the treated shoots of Canada thistle 9 WAT and tank mixtures of nicosulfuron with 2,4-D or dicamba caused 98 to 100% injury. Primisulfuron applied at 0.018 lbs/A gave 98% Canada thistle injury and tank mixtures provided similar results. However, the number of shoots regrowing from the treated plant was less following combinations of primisulfuron with 0.25, 0.38, and 0.5 lbs/A 2,4-D compared to primisulfuron applied alone. Following the 9-week rating all plants in each pot were clipped at the base and Canada thistle regrowth was examined 5 weeks after clipping. All tank mixtures with nicosulfuron reduced regrowth compared to the controls. However, only the 0.5 lbs/A 2,4-D and 0.25 lbs/A dicamba tank mixtures with primisulfuron reduced Canada thistle regrowth.

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# EVALUATION OF POSTEMERGENCE APPLICATIONS OF TRIBENURON METHYL FOR BUNCHBERRY CONTROL IN LOWBUSH BLUEBERRIES

David E. Yarborough and Timothy M. Hess[1]

## ABSTRACT

Bunchberry has been increasing in Maine lowbush blueberry fields with the use of hexazinone. A June application of tribenuron methyl suppressed bunchberry and stimulated blueberry buds but produced a slight reduction in yield.

## INTRODUCTION

Bunchberry (*Cornus canadensis* L.) invades space in and among commercial lowbush blueberry (*Vaccinium angustifolium* Ait.) clones and has a similar growth pattern to blueberry making selective control difficult (Yarborough and Bhowmik, 1989). Bunchberry invades barren areas left open by herbicide applications of hexazinone more rapidly than blueberries (Yarborough and Bhowmik, 1993) and produces an undesirable fruit. While glyphosate may be used to suppress pure stands of bunchberry, there is no selective measure for bunchberry growing within the blueberry clone.

The objective of this experiment was to test the effectiveness of tribenuron methyl, with and without a surfactant and at different rates and dates, to suppress bunchberry and to assess its effect on growth and yield of lowbush blueberry.

## METHODS

A split-split block experiment was set out at Blueberry Hill Farm, Jonesboro, ME on a Colton sandy loam soil in June 1991. The experimental design had four rates, with or without surfactant, applied on two dates with five repetitions for a total of 80 plots. Plot size was 10 by 16 feet with 3 by 16 foot alleyways and two, 1 $ft^2$ count plots per split-plot. Pre-treatment bunchberry counts were taken in early June and treatments applied on June 20 or July 24, 1991 at 0, 0.14, 0.28, or 0.57 oz ai/a. Efficacy was evaluated in July and August using an injury rating of 0 to 10 with 0 having no injury and 10 being dead. Stems were cut in October 1991 and measured for total number of stems and number of laterals and buds. Number of bunchberry was counted again in June, 1992 and plots were harvested in August 1992. Data were analyzed by analysis of variance using the SAS GLM procedure (SAS,1985).

## RESULTS

The June application of tribenuron methyl resulted in better bunchberry suppression and injury as compared to the July treatment (Table 1) but also produced more visible blueberry injury. The treatments had no affect on number of stems or length but the buds increased with

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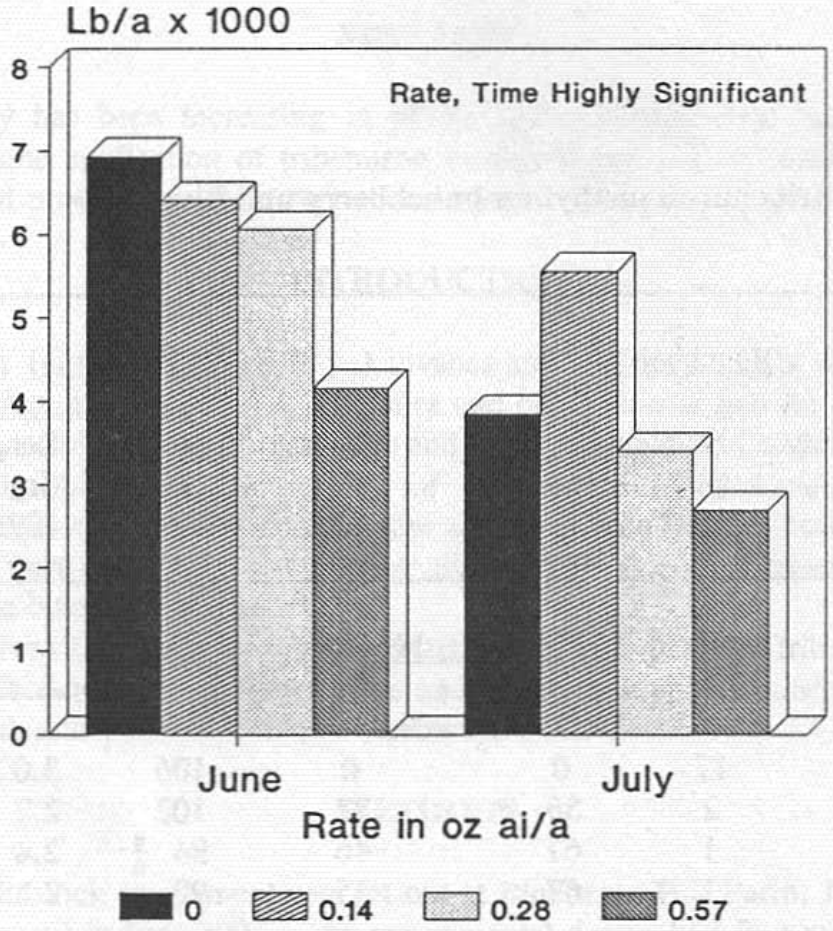
increasing rates of tribenuron methyl. Blueberry yield was reduced as tribenuron methyl rates were increased, and the July treatment had lower yields as compared to the June application (Figure 1). Use of a surfactant did not increase suppression of bunchberry or affect yield.

**Table 1. Effect of tribenuron methyl on bunchberry and blueberry.**

| | Bunchberry | | | | Blueberry | | |
|---|---|---|---|---|---|---|---|
| | Number ($ft^2$) 1991 | Number ($ft^2$) 1992 | Injury (%) 1991 | Injury (%) 1991 | Number ($ft^2$) 1991 | Length (in) 1991 | Buds ($ft^2$) 1991 |
| Application date | | | June 20, 1991 | | | | |
| Rate (oz ai/a) | | | | | | | |
| 0 | 22 | 17 | 0 | 0 | 106 | 3.0 | 3.8 |
| 0.14 | 27 | 2 | 56 | 72 | 102 | 2.7 | 3.7 |
| 0.28 | 26 | 1 | 67 | 46 | 94 | 2.4 | 5.8 |
| 0.57 | 39 | 1 | 67 | 35 | 99 | 2.8 | 5.3 |
| Application date | | | July 14, 1991 | | | | |
| Rate (oz ai/a) | | | | | | | |
| 0 | 22 | 14 | 0 | 0 | 95 | 2.7 | 2.4 |
| 0.14 | 21 | 10 | 0 | 0 | 108 | 2.8 | 2.8 |
| 0.28 | 24 | 9 | 0 | 0 | 103 | 3.1 | 3.1 |
| 0.57 | 37 | 7 | 10 | 0 | 86 | 3.0 | 3.7 |
| Significance | | | | | | | |
| Rate | ** | ** | ** | ** | NS | NS | * |
| Time | ** | ** | ** | ** | NS | NS | ** |
| Rate by Time | NS | ** | ** | ** | ** | * | NS |

**=highly significant, *=significant, NS=nonsignificant, injury rating 0%=no effect 100%=dead

Figure 1. Effect of tribenuron methyl rate and timing on blueberry yield




## CONCLUSION

Tribenuron methyl at the 0.14 or 0.28 oz ai/a applied in late spring resulted in good bunchberry suppression and increased blueberry buds but produced a slight reduction in blueberry yield. Use of a surfactant did not increase bunchberry control or blueberry injury. These favorable results warrant further research on tribenruon methyl for selective control of bunchberry in lowbush blueberry fields.

## LITERATURE CITED

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Yarborough, D.E., and P.C. Bhowmilk 1993. Lowbush blueberry-bunchberry competition.

# ENVIRONMENTAL MONITORING OF SMOOTH CRABGRASS GERMINATION

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## ABSTRACT

There is little information available on the environmental requirements for smooth crabgrass [Digitaria ischaemum (Schreb.) Muhl.] seed germination. Smooth crabgrass seedlings have appeared in open stands of turf at Silver Spring, MD between 18 and 26 April since 1980. However, it is unknown when to expect the major crabgrass germination period or when germination ceases during a season. The objective of this study is to utilize air and soil temperature data from a field monitoring station to accurately determine when initial crabgrass germination occurs, when the major germination period(s) are, and how long into the season to expect smooth crabgrass germination. Environmental information could help maximize herbicide use and possibly reduce herbicide inputs and dollars spent on controlling smooth crabgrass.

The study was initiated on a stand of 'Fylking' Kentucky bluegrass (Poa pratensis L.) with a history of heavy smooth crabgrass infestations. The area was fertilized with 49 kg N $ha^{-1}$ on 10 April 1992 and treated with a pre-packaged mixture of 2,4-D + dicamba + MCPP on 20 April 1992 to control broadleaf weeds. Smooth crabgrass seed germination was monitored on a weekly basis from April to September under two mowing heights of 3.7 cm and 6.4 cm. Plots were 1.5 by 4.5 m and arranged in a randomized complete block design with four replications. The site was mowed bi-weekly with a rotary mower. An environmental monitoring system was installed on 10 April 1992. A CR10 Measurement and Control Module (Campbell Scientific, Logan, Utah) was used to operate soil and air temperature sensors, and to collect and store the data. Soil temperatures were measured across both mowing heights at three depths: 1) 0.0 cm where sensors were placed adjacent to plant crowns; 2) 2.5 ± 0.5 cm soil depth; and 3) 5.0 ± 0.5 cm soil depth. Air temperatures were measured at 30 cm above the soil surface. Soil and air temperatures were recorded at 5 minute intervals and averaged on an hourly basis. All recorded data were temporarily stored in the CR10 Control Module then transferred to a laptop computer for further storage and analysis.

Smooth crabgrass seedlings were first observed in bareground areas of the turf on 26 April 1992. Seedlings were counted weekly by randomly dropping a 10 by 10 cm grid three times in each plot between late April and mid-July. Beginning on 15 July 1992 a new system based on a fixed 625 $cm^2$ grid was begun. Each plot contained three fixed grids and each week seedlings were counted then removed. Under low mowing, the first crabgrass seedlings began to emerge from 27 April to 3 May when average weekly minimum and maximum soil temperatures at crown level reached 12 and 22°C; respectively. The average minimum and maximum air temperatures for the week of 27 April to 3 May were 6 and 21°C; respectively. Since air temperatures were below normal for May (average monthly minimum and maximum were 8 and 21°C; respectively) smooth crabgrass seed germination was sparse with higher seedling counts observed in low cut plots. The major smooth crabgrass seed germination period began in early June. By 15 June 1992, there was an average of three crabgrass seedlings/100 $cm^2$ in low cut plots versus only one seedling/100 $cm^2$ in high cut turf. Under low mowing, average minimum and maximum temperatures at crown level associated with the major smooth crabgrass seed germination period of 15 June to 13 July 1992 were 20 and 31°C; respectively. Also, from 15 June to 13 July 1992, average minimum and maximum air temperatures were 14 and 27°C; respectively. Smooth crabgrass seed germination after 10 August was sparse, but continued into late September.

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# WEED MANAGEMENT IN FULL-SEASON NO-TILL SOYBEANS

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## ABSTRACT

Conservation tillage requirements will lead to increased production of full-season soybeans [Glycine max (L.) Merr.] that are planted no-till into a cover crop or previous crop residue. This practice requires control of existing vegetation and weeds and grasses that emerge following planting. For this reason, field studies were conducted in 1992 to investigate preemergence applications of imazaquin for control of annual broadleaf weeds in soybeans. Treatments included pendimethalin (1 lb ai/A) or metolachlor (2.0 lb ai/A) for annual grass control and glyphosate for control of existing vegetation. Treatments were applied in 10 gpa on April 7 and April 29 (30 and 7 days respectively, preplant) and soybeans ('Asgrow 5403') were planted on May 6, 1992, into a site containing residue from corn harvested for grain in 1991. Adequate rainfall was received within 6 days of each herbicide application and throughout the summer. Winter annual weeds consisted primarily of horseweed (Conyza canadensis L.) Italian ryegrass (Lolium multiflorum L.) and chickweed (Stellaria media L.). Control of existing vegetation, although slow to develop, was generally good with treatments containing either 0.6 or 1.2 lb ai/A glyphosate. High populations of both common ragweed (Ambrosia artemisiifolia L.) and pitted morningglory (Ipomoea lacunosa L.) developed after planting and were not adequately controlled by imazaquin treatments. Control of giant foxtail (Setaria faberi Herrm.), the dominant annual grass in the study, did not differ significantly between treatments containing 1 lb ai/A pendimethalin and those containing 2 lb ai/A metolachlor. Control of summer annual species was higher from applications made 7 days preplant than those made 30 days preplant. In all instances, control of broadleaf weeds could have been enhanced by the use of an appropriate postemergence broadleaf herbicide.

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# DEVELOPMENT OF AN IDENTIFICATION MANUAL FOR WEEDS OF THE NORTHEASTERN UNITED STATES

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## ABSTRACT

The use of a weed identification manual is the first step in determining the most appropriate weed management strategy in any cropping system. Such manuals are essential tools for growers, consultants, Cooperative Extension agents, IPM scouts, turf and landscape managers, weed science students, and dealers and sales support personnel, who must tailor weed management strategies for specific weed problems.

Several weed identification manuals are available for regions of the country other than the Northeast, unfortunately they do not cover many of the important species in our geographic area. Of the 2 weed identification manuals produced for the Northeastern U. S., one has not been updated in 40 years, and the other is out of print. Both are limited in scope, illustrated with low quality line drawings, and contain cursory descriptions written with inconsistent terminology. Taxonomic manuals and floras are available for the Northeast but these use specialized terms that limit their utility except to highly trained taxonomists, lack illustrations and photographs, or do not have the information that weed control professionals need to know about a given species.

The primary objective of this project is to provide the agricultural and horticultural communities with an updated, practical guide of the identification of common and economically important weeds of vegetable, orchard, and agronomic crops, as well as nurseries, gardens, and turf found in the Northeastern United States. A second objective is to collaborate with the authors of two computer databases for weed identification to provide easy to use, interactive alternatives for identifying unknown weeds. The two systems are: *W.E.E.D.S.*- a DOS based system, and *The Weed Identification Key System*- which is designed for use on Macintosh computers.

The text will be organized in the following manner:

I. **Table of Contents**
II. **Glossary of Terminology** (with illustrations)
III. **Plant Descriptions**: Each will include, correct names and synonymy, general description (life cycle and growth habit), vegetative characteristics (of seedlings and mature specimens), reproductive characteristics (including structures and life cycle times), post-senescence characteristics, similar species (including distinguishing characteristics), habitats, distribution map, line drawings, and color pictures (various stages of growth and key characteristics).
IV. **Character Identification Index:** a listing of weed species with easy to recognize characteristics, e.g. spiny to touch, basal rosette, milky sap, etc.
V. **Weed Identification Key**
VI. **Index**

This project was initiated in the fall of 1991. Two groups of descriptions have been completed and have been published in issues number 4 and 6 of *Weed Facts*, a Cornell Cooperative Extension fact sheet series. The first phase, "Weeds of Turf, Landscape, and Nurseries," will be completed by mid- 1993. Contingent upon available funding, the completed guide, including weeds of agronomic, forage, and horticultural crops of the Northeastern U. S., should be published in late 1994 or early 1995.

# LIVING MULCH FOR FIELD-GROWN NURSERY CROPS

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## ABSTRACT

Field studies were conducted in 1992 to examine the feasibility of utilizing subterranean clover (Trifolium subterraneum L. 'Mt Barker'), a winter annual forage species, as a living mulch for weed and erosion control in field-grown nursery crops. Perennial grasses are now widely used as between-row living mulches in shade tree production in the Northeast. However the requirement for frequent mowing prohibits the use of grass sod in narrow row field-grown shrubs.

Subterranean clover plots were established in late August, 1991 at the Long Island Horticultural Research Laboratory (LIHRL) and at two commercial nurseries on eastern Long Island. At each site, a different woody species had been recently planted: arborvitae (Thuja occidentalis L. 'Elegantissima') and yew (Taxus x media Rehd. 'Hatfieldii') at LIHRL, winged euonymus (Euonymus alata (Thunb.) Siebold 'Compacta') at one nursery and weeping hemlock (Tsuga canadensis L. 'Sargentii')at the other nursery. The treatments consisted of different clover seeding rates ranging from 10 to 160 pounds per acre. The seed was broadcast within and between rows and hand raked. Clover and weed cover and plant growth were measured throughout the 1992 growing season.

The results indicate that the clover survived the winter fairly well. At each site, a seeding rate of 80 pounds per acre resulted in greater than 80% clover ground cover in April. Winter annual weed cover was lowest at this seeding rates, indicating subclover is a strong weed competitor when it is well established. The clover flowered and set seed from April through June. The plants fully senesced during the month of July. New seedlings became established during August and September.

In general, the four ornamental species tolerated the clover fairly well. New growth at the end of the season was not significantly depressed in any of the species. However hemlock growth was depressed early in the season by the high seeding rates. On the other hand, the lower clover seeding rates allowed too many winter and summer annual weeds to compete, suppressing taxus and hemlock in June. Averaging the results over the three sites, it appears that a seeding rate between 40 and 80 pounds per acre can optimize weed control and minimize interference with the ornamental species.

An ancillary study examining the response of established subterranean clover to residual herbicides was conducted at LIHRL. Treatments were applied to actively growing clover on April 4, 1992. Visual evaluation indicated that simazine, oxyfluorfen and asulam can cause significant injury to clover, while oryzalin, pendimethalin, metolachlor and Rout (granular oxyflourfen and oryzalin) were relatively safe to use at this time of year. The results of these studies indicate that a subterranean clover living mulch is a viable option for weed suppression in field nurseries, but weed control will not be adequate without some supplemental assistance from herbicides.

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# PUCCINIA PUNCTIFORMIS AFFECTS GROWTH AND REPRODUCTION OF CIRSIUM ARVENSE

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## ABSTRACT

The rust, Puccinia punctiformis causes nonvigorous, etiolated growth in Canada thistle, Cirsium arvense. To be a viable biological control agent, P. punctiformis must reliably infect Canada thistle plants and proliferate in populations of Canada thistle. Experiments were conducted to determine the effect of pre- and post-inoculation temperature on rust infection and subsequent reproduction of Canada thistle. The influences of Canada thistle genotype and gender on susceptibility to the rust were also determined.

Roots from Canada thistle clones of known gender were cut into 5 cm segments and teliospores of P. punctiformis were applied in a water suspension to discernable root buds (adventitious shoots). Root segments were planted in soil and then exposed to one of several temperatures: 5, 10, 15, 20, 25, and 30 C for two weeks prior to being placed in a greenhouse under a 14 h photoperiod. In one experiment, Canada thistle roots were maintained at 10 or 20 C for 2 wk prior to inoculation. Percent infection, flowering, and height were measured periodically for 16 wk following inoculation when biomass distribution and vegetative reproduction were also measured.

Infection by P. punctiformis reduced flowering and vegetative reproduction in Canada thistle. Although infected shoots tended to be tall and spindly, shoot dry weight was not uniformly affected by infection. Infection by P. punctiformis did reduce root dry weight in Canada thistle. Infection was most successful when Canada thistle roots were maintained at 5, 10, or 15 C following inoculation. It is likely that cooler temperatures slowed root bud growth and allowed greater time for infection to develop. Exposure of roots to different temperatures prior to inoculation did not affect infection. All Canada thistle clones, regardless of gender, were susceptible to P. punctiformis. Inoculating Canada thistle roots with P. punctiformis and planting infected roots in a stand of Canada thistle may provide an effective way to initiate biological control and management of stands of Canada thistle in the field.

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# DIFFERENTIAL SENSITIVITY OF SOYBEAN CULTIVARS TO OZONE AND PARAQUAT

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## ABSTRACT

The effects of ozone and paraquat treatments on leaf homoglutathione ( $\gamma$ - glutamylcysteinylalanine) content were compared in ozone-insensitive (Essex) and ozone-sensitive (Forrest) soybean (Glycine max L.) cultivars. Treatment with ozone caused a gradual increase in reduced homoglutathione (hGSH) in leaves of Essex, followed by a decline after 6 hours and an increase in glutathione-linked disulfides (GSSX). The initial increase in hGSH may represent an adaptive change to oxidative stress. In leaves of Forrest, levels of hGSH increased only during the first hour of fumigation, and were then decreased without an equivalent accumulation of GSSX. The initial induction of hGSH was lower in Forrest, and this cultivar contained lower amounts of leaf hGSH at equivalent treatment times than were present in Essex. Paraquat treatment caused an early increase in hGSH content of Essex, followed by a depletion, as observed after ozone exposure. The same trends were observed in leaves of Forrest but at slower rates; levels of oxidized disulfides were increased after longer exposures to paraquat in this cultivar but they were not sufficient to account for the depletion of hGSH. Further treatments evaluated hGSH content and oxidative stress after ozone or paraquat exposure during plant development. In both cultivars, differential sensitivity was observed between the primary leaf and the first and second trifoliates.

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# Effect of Three Safeners Against the Herbicidal Activity of DPX-E9636 in Corn[1]

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## Abstract

Three safeners were tested for their ability to protect corn from the herbicidal activity of DPX-E9636, a sulfonylurea compound. The safeners tested were dichlormid, R-29148, and BAS-145138. All three safeners gave at least partial protection to corn from DPX-E9636. This study shows that with the addition of a safener, DPX-E9636 could become a useful herbicide in corn culture. Also, in situations where corn is rotated with a crop using DPX-E9636, corn seeds could be safened against any residual action of the herbicide.

## Introduction

DPX-E9636 [N-((4,6-dimethoxypyrimidin-2yl)aminocarbonyl)-3-(ethylsulfonyl)-2-pyridinesulfonamide] is a relatively new sulfonylurea herbicide that has shown preemergence and postemergence broad spectrum weed control in potato culture (1,3). Also, in field corn Hahn (2) has demonstrated excellent foxtail and wild mustard control with early postemergence application of DPX-E9636 at 35 g/ha. Consequently, use of this herbicide in both potato and corn cultures is anticipated.

In the present study the safening activity of dichlormid (2,2-dichloro-N-N-di-2-propenylacetamide), R-29148 [3-(dichloroacetyl)-2,2,5-trimethyloxazolidine], and BAS-145138 [1-dichloroacetylhexahydro-3,3,8α-trimethyl-pyrrolo-(1,2-α)-pyrimidin-6-(2H)-one] on corn (*Zea mays* L.) treated with DPX-E9636 was compared. All three safeners gave corn at least partial protection from the herbicidal activity of DPX-E9636.

## Materials and Methods

Corn seeds were imbibed for 6 h in 1.5 mM concentrations of dichlormid, R-29148, and BAS-145138. The treated seeds were sown in 8-cm styrofoam pots (15 seeds per pot) containing moist vermiculite that had been previously treated on the surface with different rates of DPX-E9636. All herbicide applications were

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made in 5 ml of water and with the aid of a small atomizer at a pressure of about 70 k/Pa. The bottoms of the pots were punctured several times to allow good drainage and the seeds were covered with untreated moist vermiculite to a depth of about one cm. Petri dish halves were used as holders for the pots to catch drainage and as an indirect method of providing water and nutrients. The plants were grown in a growth chamber under constant conditions of light (152 uE $m^{-2}s^{-1}$, 16 h light and 8 h dark) and temperature (22±1C). After shoot emergence 30 ml of 1/2 strength Hoagland solution was applied daily to each pot. After 13 days the seedlings were removed from the pots and the roots thoroughly washed. The ten largest seedlings (determined by shoot length) from each pot were selected and their shoot length, root length, fresh weight, and dry weight determined. All experiments were replicated four times and all data were subjected to analysis of variance.

## Results and Discussion

Dichlormid protected corn from the herbicidal influence of DPX-E9636. At the lowest rate (5 uM) tested, DPX-E9636 caused a 41% drop in shoot length, a 29% drop in shoot fresh weight, and 28% drop in dry weight. With the addition of 1.5 mM dichlormid shoot length, fresh weight, and dry weight were not significantly different from the control (Table 1). At the highest rate (25 uM) tested, DPX-E9636 caused reductions in shoot length, fresh weight, and dry weight of 54, 50 and 46%, respectively. In the presence of 1.5 mM dichlormid those reductions were 24, 23, and 22% (Table 1). Similar protection by dichlormid was afforded root growth in corn treated with DPX-E9636 (Table 1).

Table 1. Safening influence of dichlormid (Dichl) on the herbicidal activity of DPX-E9636 (DPX) on the growth of corn.

| | | SHOOTS | | | ROOTS | | |
|---|---|---|---|---|---|---|---|
| DPX (uM) | Dichl (mM) | Length (mm) | Fr Wgt (mg/pl) | Dry Wgt (mg/pl) | Length (mm) | Fr Wgt (mg/pl) | Dry Wgt (mg/pl) |
| 0 | 0.0 | 148 | 480 | 46 | 170 | 743 | 67 |
| 5 | 0.0 | 88 | 340 | 33 | 141 | 578 | 58 |
| 5 | 1.5 | 144 | 478 | 46 | 166 | 860 | 76 |
| 10 | 0.0 | 82 | 314 | 33 | 104 | 406 | 49 |
| 10 | 1.5 | 129 | 429 | 41 | 153 | 777 | 73 |
| 25 | 0.0 | 68 | 241 | 25 | 83 | 287 | 35 |
| 25 | 1.5 | 112 | 369 | 36 | 131 | 607 | 56 |
| LSD | 5% | 5.0 | 45 | 4.5 | 17 | 94 | 9.5 |
| | 1% | 6.8 | 61 | 6.0 | 23 | 127 | 12.8 |

Application of 5 uM DPX-E9636 reduced shoot length, fresh weight, and dry weight 33, 19, and 16%, respectively. However, when 1.5 mM R-29148 was added no reductions were observed (Table 2). When the rate of DPX-E9636 was doubled to 10 uM protection by R-29148 was still almost complete. For example, the shoot length, fresh weight, and dry weight of corn treated with 10 uM DPX-E9636 were reduced 32, 24, and 20%, respectively. In the presence of 1.5 mM R-29148 those reductions were only 9, 6, and 9% (Table 2). As with dichlormid, root growth of corn treated with DPX-E9636 was protected by R-29148 (Table 2).

Table 2. Safening influence of R-29148 (R-29) on the herbicidal activity of DPX-E9636 (DPX) on the growth of corn.

| | | SHOOTS | | | ROOTS | | |
|---|---|---|---|---|---|---|---|
| DPX (uM) | R-29 (mM) | Length (mm) | Fr Wgt (mg/pl) | Dry Wgt (mg/pl) | Length (mm) | Fr Wgt (mg/pl) | Dry Wgt (mg/pl) |
| 0 | 0.0 | 149 | 445 | 44 | 130 | 522 | 53 |
| 5 | 0.0 | 115 | 362 | 37 | 135 | 399 | 48 |
| 5 | 1.5 | 161 | 497 | 49 | 163 | 511 | 55 |
| 10 | 0.0 | 102 | 339 | 35 | 109 | 348 | 40 |
| 10 | 1.5 | 136 | 417 | 40 | 165 | 430 | 47 |
| 25 | 0.0 | 76 | 262 | 31 | 83 | 230 | 33 |
| 25 | 1.5 | 112 | 353 | 33 | 151 | 409 | 43 |
| LSD | 5% | 5.0 | 37 | 3.5 | 16 | 69 | 5.0 |
| | 1% | 6.7 | 50 | 4.8 | 22 | 93 | 7.1 |

Table 3. Safening influence of BAS-145138 (BAS) on the herbicidal activity of DPX-E9636 (DPX) on the growth of corn.

| | | SHOOTS | | | ROOTS | | |
|---|---|---|---|---|---|---|---|
| DPX (uM) | BAS (mM) | Length (mm) | Fr Wgt (mg/pl) | Dry Wgt (mg/pl) | Length (mm) | Fr Wgt (mg/pl) | Dry Wgt (mg/pl) |
| 0 | 0.0 | 147 | 483 | 45 | 177 | 641 | 51 |
| 5 | 0.0 | 105 | 334 | 29 | 122 | 454 | 39 |
| 5 | 1.5 | 130 | 475 | 42 | 165 | 719 | 54 |
| 10 | 0.0 | 88 | 340 | 33 | 99 | 366 | 36 |
| 10 | 1.5 | 132 | 460 | 42 | 157 | 657 | 58 |
| 25 | 0.0 | 74 | 301 | 34 | 60 | 243 | 28 |
| 25 | 1.5 | 103 | 381 | 33 | 129 | 478 | 42 |
| LSD | 5% | 6.7 | 25 | 3.2 | 12 | 59 | 4.9 |
| | 1% | 9.0 | 34 | 4.3 | 17 | 79 | 6.6 |

Compared to dichlormid and R-29148, BAS-145138 was slightly less effective as a safener for corn treated with DPX-E9636. Shoot length of corn treated with 10 uM DPX-E9636 was reduced 40%, but with the addition of 1.5 mM BAS-145138 only a 10% reduction was observed (Table 3). Shoot fresh weight and dry weight of corn treated with 10 uM DPX-E9636 and safened with 1.5 mM BAS-145138 were not significantly different from the control (Table 3). BAS-145138 gave good protection to root growth against the herbicidal activity of DPX-E9636 (Table 3).

The present study shows that, with the addition of a safener, DPX-E9636 could prove to be a useful herbicide in corn culture. Also, in situations where corn is rotated with a crop using DPX-E9636, corn seeds could be safened against any residual action of the herbicide.

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# Effect of DPX-E9636 on Growth and Enzyme Activity in Barley and Pea[1]

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## Abstract

DPX-E9636 inhibited the growth of both barley and pea. Pea shoot growth was much more sensitive to the herbicide than barley shoot growth. Pea root growth was relatively tolerant of DPX-E9636. Barley acid phosphatase activity was not affected by DPX-E9636, but alkaline phosphatase was stimulated. Nitrate reductase activity in barley was strongly stimulated by DPX-E9636. There was also an increase in peroxidase activity in barley treated with DPX-E9636. Acid and alkaline phosphatase activity in pea was only slightly stimulated by DPX-E9636 while nitrate reductase activity was stimulated. DPX-E9636 did not affect the activity of peroxidase in pea.

## Introduction

The experimental compound DPX-E9636 [N-((4,6-dimethoxypyrimidin-2-yl) aminocarbonyl)-3-(ethylsulfonyl)-2-pyridinesulfonamide] is a sulfonylurea herbicide and as such inhibits cell division and growth in plants. This type of herbicide blocks protein synthesis by inhibiting the activity of acetolactate synthase an enzyme which is necessary for the synthesis of three essential amino acids, leucine, valine, and isoleucine (1,8).

DPX-E9636 has been used successfully in potato culture to control a broad spectrum of annual and perennial grasses as well as many broadleaf weeds (4,7). Good annual grass and broadleaf weed control with DPX-E9636 in field corn has also been demonstrated by Hahn (3).

In the present study the effect of DPX-E9636 on the growth of pea (*Pisum sativum* L.) barley (*Hordeum vulgare* L.) was studied. Also, its effect on the activity of several enzymes in these plants was determined.

## Methods and Materials

Barley and pea seeds were soaked for 6 h in different concentrations of DPX-E9636. The imbibed seeds were sown in 8-cm styrofoam pots (15 seeds per pot) containing moist vermiculite and grown in a growth chamber under constant conditions of light (152 uE $m^{-2}s^{-1}$, 16 h light and 8 h dark) and temperature (22 1°C). After shoot emergence 40 ml of 1/2 strength Hoagland solution were applied daily to each pot. After 10 days (barley) and 13 days (pea) the

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seedlings were removed from the pots and the roots thoroughly washed. The ten largest seedlings (determined by shoot length) from each pot were selected and their shoot length, root length, fresh weight, and dry weight determined.

For enzyme studies 2 g samples of pea and barley leaf tissue were ground in a chilled mortar with 10 ml of phosphate buffer (pH 7.8) containing 0.005 M cysteine and 0.0025 M EDTA. The sample was filtered through Whatman No. 4 filter paper and the extract centrifuged for 5 min at 13,000 G at 18°C. The supernatant (crude extract) was collected and used to assay the activity of acid phosphatase, alkaline phosphatase, nitrate reductase, and peroxidase.

To assay for nitrate reductase activity 1 ml of crude extract was diluted with 0.4 ml of 0.1 N $KNO_3$ and 1 ml of 0.001 N NADH (as an $H^+$ donor) and then incubated for 1 h at 27°C. The reaction was terminated by adding 1 ml of 6% zinc acetate, the sample cooled for 10 min at -10°C in a freezer, and then centrifuged for 5 min at 13,000 G. After 1 ml of the supernatant was diluted with 0.5 ml $H_2O$, 2 ml of reagent mixture (1 ml of 1% sulfanilic acid + 1 ml of 0.02% N-naphtylethylenediamine) was added and allowed to stand for 30 min. The release of $NO_2$ was determined at 540 nm with a Perkin-Elmer double beam spectrophotometer. One unit equals the amount of $NO_2$ in uM released in 1 h by 1 g of fresh tissue.

To assay for peroxidase activity 0.1 ml of crude extract was diluted with 1.9 ml phosphate buffer (pH 7), 0.1 ml of 1% p-phenylenediamine, and 0.1 ml of 0.04% hydrogen peroxide. The hydrogen peroxide is added to the reaction mixture just before being read with the spectrophotometer. The optical density (OD) of the reaction mixture was read at 485 nm every 30 sec for 2 min. One unit of activity equals the increase in OD in 1 sec caused by 100 g of fresh tissue.

To assay for acid phosphatase activity 0.05 ml of crude extract was diluted with 0.95 ml of buffer (pH 4.8) substrate containing 0.165% p-nitrophenylphosphate and incubated for 30 min at 40°C. After 5 ml of 0.02 N NaOH was added to the reaction mixture the OD was read at 405 nm. The addition of NaOH stops the reaction and the p-nitrophenol liberated by the phosphatase (both acid and alkaline) forms a yellow anion. One phophatase unit is the amount of enzyme in 100 g of fresh tissue which liberates 1 mM p-nitrophenol at 40°C.

To assay for alkaline phosphatase activity 0.1 ml of crude extract was diluted with 0.9 ml of buffer (pH 10.5) substrate containing glycine and 0.165% p-nitrophenylphosphate and incubated for 30 min at 40°C. After 5 ml of 0.02 N NaOH was added to the reaction mixture the OD was read at 405 nm. See definition of phosphatase unit above.

Peroxidase activity was determined according to the methods of Lück (6) and the phosphatase activity according to the methods of Linhardt and Walter (5). All experiments were replicated four times.

## RESULTS AND DISCUSSION

The growth of barley was inhibited by DPX-E9636 over a concentration range of 0.5 to 50 uM. At 10 uM DPX-E9636 there was a 43% inhibition of shoot

fresh weight and dry weight were similarly affected. For example, at 10 uM fresh weight was down 41% and dry weight 43%. At 50 uM DPX-E9636, shoot fresh weight was inhibited 55% and dry weight was down 56% (Table 1). Barley root growth responded to DPX-E9636 in the same manner as shoot growth, but was slightly less sensitive (Table 1).

Table 1. Effect of DPX-E9636 on the growth of barley.

| E9636 (uM) | SHOOT Length (mm) | SHOOT Fr Wt (mg/pl) | SHOOT Dry Wt (mg/pl) | ROOT Length (mm) | ROOT Fr Wt (mg/pl) | ROOT Dry Wt (mg/pl) |
|---|---|---|---|---|---|---|
| 0.0 | 141 | 137 | 18.0 | 149 | 84 | 10.3 |
| 0.5 | 128 | 113 | 15.5 | 144 | 78 | 9.5 |
| 1.0 | 116 | 117 | 14.0 | 127 | 76 | 9.0 |
| 5.0 | 97 | 101 | 11.8 | 110 | 67 | 7.3 |
| 10.0 | 81 | 81 | 10.3 | 98 | 63 | 7.3 |
| 50.0 | 54 | 62 | 8.0 | 64 | 43 | 5.5 |
| LSD 5% | 8.8 | 14.5 | 1.6 | 11.5 | 8.1 | 1.6 |
| 1% | 12.1 | 19.9 | 2.2 | 15.8 | 11.1 | 2.2 |

The growth of pea was three orders of magnitude more sensitive to DPX-E9636 than barley growth. For example, 8 nM (note the unit used) DPX-E9636 caused decreases in pea shoot length, fresh weight, and dry weight of 61, 56, and 52%, respectively (Table 2). Compared to shoot growth, pea root growth was much less sensitive to the herbicide. At 8 nM DPX-E9636 the decreases in root growth in length, fresh weight, and dry weight were 0, 30, and 19%, respectively (Table 2).

Table 2. Effect of DPX-E9636 on the growth of pea.

| E9636 (nM) | SHOOT Length (mm) | SHOOT Fr Wt (mg/pl) | SHOOT Dry Wt (mg/pl) | ROOT Length (mm) | ROOT Fr Wt (mg/pl) | ROOT Dry Wt (mg/pl) |
|---|---|---|---|---|---|---|
| 0 | 119 | 758 | 73 | 120 | 645 | 31 |
| 2 | 117 | 792 | 69 | 118 | 594 | 27 |
| 4 | 106 | 722 | 64 | 121 | 628 | 28 |
| 6 | 66 | 456 | 45 | 116 | 513 | 26 |
| 8 | 46 | 333 | 35 | 120 | 454 | 25 |
| 10 | 38 | 265 | 27 | 116 | 427 | 22 |
| LSD 5% | 5.0 | 47.7 | 3.7 | 9.4 | 81 | 3.4 |
| 1% | 6.8 | 65.0 | 5.1 | 12.8 | 110 | 4.6 |

The effect of DPX-E9636 on the activity of acid phosphatase, alkaline phosphatase, nitrate reductase, and peroxidase in barley and pea was deter-

They are ubiquitous to plants and are essential participants in many important metabolic reactions. Nitrate reductase, found in the cell cytoplasm, is the first enzyme involved in the nitrate assimilation pathway. It is essential for the conversion of nitrogen from an oxidized state to a reduced state so that it can be incorporated into numerous important organic compounds. Peroxidase enzymes are common to all higher plants. In the presence of $H_2O_2$, peroxidase catalyzes the oxidation of substrates such as phenols, aromatic-, primary-, secondary-, and tertiary amines and certain heterocyclic compounds such as ascorbic acid and indole. Also a large number of H-donors are oxidized in coupled oxidation in which the peroxidase system results in the formation of an oxidation product which, in turn, oxidizes another compound (2).

The activity of acid phosphatase in barley leaves was not affected by DPX-E9636 over a concentration range of 5 to 100 uM (Table 3). Alkaline phosphatase activity, however, was stimulated by the herbicide. There was a 32% increase in activity in barley treated with 20 uM DPX-E9636 (Table 3).

DPX-E9636 had a dramatic dose-related effect on the activity of nitrate reductase in barley. At the lowest concentration of DPX-E9636 used (5 uM), there was a 121% increase in activity. At the highest concentration used (100 uM), an increase of 790% was observed (Table 3). Such an increase in nitrate reductase activity could cause an accumulation of nitrite in the leaf tissue, a circumstance that would be phytotoxic to the plant.

Peroxidase activity in barley was stimulated by DPX-E9636. At 5, 10, 20, and 50 uM DPX-E9636, increases in activity of 47, 106, 122, and 130% respectively, were observed (Table 3).

Table 3. Effect of DPX-E9636 on enzyme activity in 10 day barley seedlings. Phos = phosphatase and U = unit.

| E9636 (uM) | Acid Phos (U/100g) | (%) | Alkaline Phos (u/100g) | (%) | Nitrate Reductase (uM $NO_2$/g/h) | (%) | Peroxidase (ΔE/sec/100g) | (%) |
|---|---|---|---|---|---|---|---|---|
| 0 | 31.2 | 100 | 0.865 | 100 | 13.9 | 100 | 64.9 | 100 |
| 5 | 31.2 | 100 | 0.900 | 104 | 30.7 | 221 | 95.1 | 147 |
| 10 | 31.2 | 100 | 1.115 | 129 | 52.8 | 380 | 133.4 | 206 |
| 20 | 31.7 | 102 | 1.138 | 132 | 105.6 | 760 | 143.8 | 222 |
| 50 | 28.7 | 92 | 1.143 | 132 | 109.5 | 788 | 149.0 | 230 |
| 100 | 28.7 | 92 | 1.075 | 124 | 123.7 | 890 | 142.5 | 220 |
| LSD 5% | 2.1 | - | 0.123 | - | 24.3 | - | 20.0 | - |
| 1% | 2.9 | - | 0.169 | - | 33.3 | - | 27.4 | - |

Acid and alkaline phosphatase activity in pea was only slightly affected by DPX-E9636. At the highest concentrations of herbicide used (8 and 10 nM) the activity of both enzymes was slightly inhibited (Table 4). Nitrate reductase activity in pea was stimulated by the herbicide. DPX-E9636 at rates of 2, 4, 6, and 8 nM caused increases in activity of 26, 39, 46, and 71%, respectively (Table 4). The activity of peroxidase in pea was not significantly affected by DPX-E9636 (Table 4).

Table 4. Effect of DPX-E9636 on enzyme activity in 14 day pea seedlings. Phos = Phosphatase and U = unit.

| E9636 (nM) | Acid Phos (U/100g) | (%) | Alkaline Phos (u/100g) | (%) | Nitrate Reductase (uM $NO_2$/g/h) | (%) | Peroxidase (ΔE/sec/100g) | (%) |
|---|---|---|---|---|---|---|---|---|
| 0 | 33.9 | 100 | 2.25 | 100 | 23.0 | 100 | 58.3 | 100 |
| 2 | 33.0 | 97 | 2.21 | 98 | 29.0 | 126 | 58.2 | 100 |
| 4 | 32.7 | 96 | 2.14 | 95 | 32.0 | 139 | 54.1 | 93 |
| 6 | 31.6 | 93 | 2.04 | 91 | 33.6 | 146 | 53.7 | 92 |
| 8 | 27.8 | 82 | 1.99 | 88 | 39.4 | 171 | 53.3 | 91 |
| 10 | 26.1 | 87 | 1.80 | 80 | 39.5 | 172 | 54.8 | 94 |
| LSD 5% | 3.9 | - | 0.14 | - | 11.6 | - | 10.9 | - |
| 1% | 5.4 | - | 0.19 | - | 15.8 | - | 14.9 | - |

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# RESPONSE OF CORN AND WEEDS TO MON 12000

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## ABSTRACT

MON 12000 (Methyl 3-chloro-5-(4,6-dimethoxpyrimidin-2-ylcarbamoylsulfamoyl)-1-methylpyrazole-4-carboxylate) is a new sulfonylurea herbicide for broad-spectrum weed control. MON 12000 was evaluated in growth chamber, greenhouse, and in the field to: (i) examine the response of corn (Zea mays L.) and yellow nutsedge (Cyperus esculentus L.) to different rates of MON 12037 and (ii) determine the effectiveness of MON 13988 (safener) in protecting corn injury from MON 12037.

For the first study, corn seeds were planted in perlite:soil mixture (1:5) in 10 cm plastic pots. MON 12037 was applied preemergence at 0.1, 0.2, 0.5, 1.0, and 2.0 mM. The study was conducted in a growth chamber under 16 h light and 8 h dark with day-night temperatures of 24 and 15 C. The light intensity was 11.65 $uEm^{-2}s^{-1}$. The experiment was a randomized complete block design with four replications. Shoot height, root length, and fresh and dry weights of shoots and roots were determined 15 days after treatment (DAT). MON 12037 at 0.1, 0.2, 0.5, 1.0, and 2.0 mM reduced corn shoot height by 30, 45, 66, 69, and 80%, respectively. In general, MON 12037 strongly inhibited root development. MON 12037 at 0.1, 0.2, 0.5, 1.0, and 2.0 mM reduced root length by 50, 62, 82, 85 and 93%, respectively. In general, treatments reduced root length more than the root weight. Both fresh and dry weights of corn plants decreased as the rate of herbicide increased.

In the second study, corn seeds were soaked in 0, 0.5, 1.0, 1.5 mM of MON 13988 (safener). Treated seeds were planted in plastic pots. MON 12037 at 0.2 mM (0.74 kg $ha^{-1}$) was applied preemergence. The plants were grown under controlled conditions as above. Shoot height, root length, and fresh and dry weights of shoots and roots were determined 15 DAT. MON 12037 at 0.2 mM decreased corn shoot dry weight by 20% and root dry weight by 45%. MON 13988 at 1.5 mM protected corn injury from MON-12037 (0.2 mM). The lower rates (0.5 and 1.0 mM) of MON 13988 were not as effective in protecting corn plants as the highest rate. In conclusion, MON 13988 consistently reduced injury from MON 12037.

Two field experiments were conducted to determine the effectiveness of MON 12037 and MON 12041 (with safener) in controlling yellow nutsedge in field corn. MON 12037 at 0.018 and 0.036 kg $ha^{-1}$ was applied postemergence, while MON 12041 at 0.043 and 0.084 kg $ha^{-1}$ was applied postemergence (3- to 4-leaf stage of yellow nutsedge) in another experiment. All treatments were applied with X-77 at 0.25% (v/v). MON 12037 and MON 12041 controlled yellow nutsedge effectively (over 95%) 9 WAT, compared to the control of only 70% with bentazon at 1.1 kg $ha^{-1}$. No corn injury was observed, however, the 0.036 kg $ha^{-1}$ rate of Mon 12037 reduced corn height 3 WAT. No treatment reduced corn yield.

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# EVALUATION OF WINTER ANNUAL LEGUMES AS COVER CROPS IN THE NORTHEAST

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## ABSTRACT

Winter annual legumes were planted in September and evaluated for groundcover and phenology during the succeeding spring at Beltsville, Maryland. Hairy vetch (Vicia villosa Roth) developed a complete groundcover by early May and continued growth until senescence in late June. Bigflower vetch (Vicia grandiflora Scop.) also developed a complete groundcover but matured approximately two weeks earlier. Common vetch (Vicia sativa L.) exhibited winter injury and did not develop as complete or as early canopy development as hairy or bigflower vetch. Crimson clover (Trifolium incarnatum L.) was injured slightly by cold periods in early spring but developed a good early canopy and senesced earlier than any other species. Subterranean clover (Trifolium subterraneum L.) variety 'Mt. Barker' was more winter-hardy than varieties 'Larisa' or 'Meteora' and formed a complete and early groundcover in one out of two years. Arrowleaf clover (Trifolium vesiculosum Savi), ball clover (Trifolium nigrescens Viv.), berseem clover (Trifolium alexandrinum L.), Persian clover (Trifolium resupinatum L.), and rose clover (Trifolium hirtum All.) had problems with winter injury, poor establishment, and/or slow early growth; however, 'Yuchi' arrowleaf clover, 'Common' ball clover, 'Bigbee' berseem clover, and 'TX-RH-18' rose clover developed good groundcover by June. Because of consistently uniform groundcover development by May 1 when the first flush of weeds usually emerge at Beltsville, hairy vetch, bigflower vetch, and crimson clover should be the best cover crops for achieving early weed suppression in sustainable agricultural systems.

## INTRODUCTION

The leaf canopy of a living cover crop can be very effective at suppressing weed emergence (4). Cover crops which develop an early canopy could be important components of sustainable agricultural systems. Legume cover crops may be paticularly suited to sustainable systems if they can suppress weeds as well as contribute nitrogen to succeeding crops. Much research with winter legume cover crops has been done in the southeastern United States. However, an evaluation of winter legumes in Maryland demonstrated that many species are not adapted to the mid-Atlantic area, particularly the piedmont (3). Hairy vetch can be considered a standard of comparison as it is probably the only annual legume adapted to all areas of the northeast (2). This research was conducted to evaluate several species and

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varieties of winter annual legumes for performance at Beltsville, Maryland with an emphasis on early growth which could enhance weed suppression.

## MATERIALS AND METHODS

Varieties used in this experiment were part of tests conducted by the Southern Forage Breeders Information Exchange Group and were obtained from the Regional Plant Introduction Station at Griffin, Georgia (contact: Mr. Gilbert R. Lovell). Cover crop seed was mixed with the appropriate inoculum and broadcast by hand to 3.05 by 3.05 m plots on September 12, 1990 and September 17, 1991. Seed was firmed into the soil by driving a Brillion seeder over the plots after broadcasting. Seeding rates were 28 kg/ha for hairy vetch and bigflower vetch; 39 kg/ha for common vetch; 16 kg/ha for arrowleaf and Persian clovers; 4 kg/ha for ball clover; and 22 kg/ha for berseem, crimson, rose, and subterranean clovers. Plots were arranged in a randomized complete block design with four replications. Air and soil temperatures were recorded on a 5 s interval with a datalogger. Beginning April 15 of 1991 and 1992, weekly ratings were made of cover crop growth and phenology until senscence.

## RESULTS AND DISCUSSION

Both winters in this experiment were relatively mild for this area (Table 1). Average maximum temperatures were above freezing during the winter months and there were only 4 days in 1990-91 and 3 days in 1991-92 when the temperature remained below freezing for the entire day. Average minimum temperatures were slightly below freezing during the winter months with an absolute minimum of -11 C during both winters. Soil temperature never dropped below freezing in either year (data not shown). Cover crops probably overwintered better during these experiments than would be expected under more typical winter conditions.

Unusually hot temperatures occurred during May and June in 1991 whereas temperatures were unusually cool during the same period of 1992 (Table 1). As a result, cover crops matured and senesced earlier in 1991 than in 1992 (Table 2). Droughty weather during May and early June of 1991 also may have reduced maximum cover ratings for many species compared to those in 1992.

Percentage of the soil area covered by cover crop vegetation on April 29 was chosen as an important variable because summer weeds usually begin emerging approximately May 1. Cover crops that do not have a high degree of soil coverage at this time probably will not suppress this early flush of weed emergence. Only hairy vetch, bigflower vetch, and crimson clover had a high percentage of groundcover on this date in both years (Table 2). Crimson clover was the earliest flowering and senescing of all species tested. Slight frost-kill (approximately 10 %) of

vetch. Maryland may be the northern limit for overwintering crimson clover (2). Bigflower vetch flowered and senesced earlier than hairy vetch and may be a viable alternative to hairy vetch in cropping systems where an extended period of aggressive, viny growth by hairy vetch is undesirable. Bigflower vetch is not available from commercial sources, however, because seed shatters easily and is difficult to harvest (J. A. Mosjidis, Auburn U., personal communication).

Common vetch varieties suffered various degrees of winter injury but most varieties were able to achieve a reasonable soil coverage because of its viny growth habit (Table 2). Common vetch is recognized as being less winter-hardy than hairy vetch (2).

Arrowleaf, ball, berseem, Persian, and rose clovers were slow to develop in spring, requiring until June to achieve a maximum canopy. 'Bigbee' berseem clover and 'Hykon' rose clover suffered a high degree of winter damage in each year. 'Meechee' arrowleaf clover, 'Segrest' ball clover, and 'Hykon' persian clover did not establish well in these experiments.

'Mt. Barker' was the most winter-hardy subterranean clover variety and established a dense, uniform stand in all plots in 1992 but not in 1991. 'Larisa' and 'Meteora' subterranean clover exhibited winter injury and had inferior canopy cover to 'Mt. Barker' in each year. 'Mt. Barker' has excellent potential to suppress weeds as a living mulch (1) because of its low, densely intertwined canopy growth. However, uniform stand establishment was inconsistent in this experiment as well as other experiments in Maryland (3). It probably is adapted best to coastal areas of the northeast.

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## LITERATURE CITED

1. Enache, A. J. and R. D. Ilnicki. 1990. Weed control by subterranean clover used as a living mulch. Weed Technol

Table 1. Air temperature during cover crop evaluations at Beltsville, Maryland.

| Month | 1990-91 Average Maximum | 1990-91 Average Minimum | 1990-91 Absolute Minimum | 1991-92 Average Maximum | 1991-92 Average Minimum | 1991-92 Absolute Minimum |
|---|---|---|---|---|---|---|
| | (C) | | | | | |
| December | 11.3 | -0.3 | -7.2 | 9.7 | -0.3 | -8.6 |
| January | 7.3 | -3.7 | -11.3 | 7.4 | -2.3 | -11.4 |
| February | 11.0 | -1.5 | -8.8 | 9.2 | -1.1 | -10.6 |
| March | 13.5 | 2.2 | -5.6 | 11.3 | 1.0 | -6.5 |
| April | 19.7 | 6.6 | -2.5 | 18.5 | 6.4 | -2.1 |
| May | 27.9 | 14.1 | 6.1 | 21.8 | 9.8 | 2.6 |
| June | 29.5 | 16.4 | 9.8 | 26.8 | 15.1 | 8.3 |

ble 2. Performance of winter annual legume cover crops at Beltsville, Maryland, 1991-1992.

| ver crop | 1991 Cover rating[a] 4/29 | 1991 Cover rating[a] Maximum | 1991 Date[b] Maximum | 1991 Date[b] Senescence | 1992 Cover rating[a] 4/29 | 1992 Cover rating[a] Maximum | 1992 Date[b] Maximum | 1992 Date[b] Senescence |
|---|---|---|---|---|---|---|---|---|
| iry vetch | 88 | 100 | 5/13 | 6/7 | 100 | 100 | 4/29 | 7/1 |
| gflower vetch 'Woodford' | 87 | 96 | 5/14 | 5/27 | 100 | 100 | 5/2 | 6/15 |
| mmon vetch 'Cahaba White' | 47 | 67 | 5/27 | 5/27 | 80 | 84 | 5/3 | 6/11 |
| mmon vetch 'Nova II' | 18 | 38 | 6/3 | 5/27 | 65 | 88 | 5/15 | 6/11 |
| mmon vetch 'Vanguard' | 35 | 45 | 5/8 | 5/27 | 79 | 80 | 5/7 | 6/11 |
| mmon vetch 'Vantage' | 63 | 76 | 5/18 | 5/29 | 87 | 92 | 5/13 | 6/11 |
| rowleaf clover 'Amclo' | 58 | 82 | 6/10 | 5/31 | 41 | 79 | 6/29 | 6/25 |
| rowleaf clover 'Meechee' | 6 | 35 | 6/21 | 6/18 | 6 | 11 | 6/7 | 6/25 |
| rowleaf clover 'Yuchi' | 79 | 92 | 6/7 | 6/9 | 54 | 88 | 6/22 | 6/25 |
| ll clover 'Common' | 25 | 80 | 6/6 | 6/11 | 55 | 93 | 6/11 | 6/20 |
| ll clover 'Segrest' | 3 | 25 | 5/31 | 6/16 | 25 | 91 | 6/11 | 6/16 |
| rseem clover 'Bigbee' | 40 | 78 | 6/4 | 6/11 | 58 | 88 | 6/16 | 6/23 |
| imson clover 'Chief' | 86 | 86 | 4/29 | 5/25 | 89 | 94 | 5/11 | 5/29 |
| imson clover 'Dixie' | 77 | 88 | 4/26 | 5/13 | 84 | 86 | 5/3 | 5/25 |
| imson clover 'Tibbee' | 73 | 78 | 4/19 | 5/13 | 84 | 86 | 5/7 | 6/1 |
| rsian clover 'Abon' | 5 | 52 | 6/24 | 6/18 | 10 | 78 | 6/18 | 6/25 |
| se clover 'Hykon' | 29 | 29 | 4/29 | 5/24 | 36 | 50 | 5/25 | 6/16 |
| se clover 'TX-RH-18' | 53 | 75 | 6/7 | 6/7 | 60 | 88 | 6/16 | 6/14 |
| bterranean clover 'Larisa' | 23 | 39 | 5/24 | 5/25 | 43 | 76 | 5/18 | 6/11 |
| bterranean clover 'Meteora' | 17 | 23 | 5/20 | 5/27 | 44 | 80 | 5/18 | 6/11 |
| bterranean clover 'Mt. Barker' | 61 | 67 | 5/21 | 5/27 | 98 | 99 | 5/21 | 6/15 |

Percentage of soil area covered by cover crop vegetation.

Date on which cover crop first achieved maximum cover rating or began senescing.

# WEED MANAGEMENT IN NARROW AND WIDE ROW CORN

C. Benjamin Coffman and J. Ray Frank[1]

## ABSTRACT

Corn-weed investigations were started at the Beltsville Agricultural Research Center in 1991 to characterize responses of no-till corn ( Zea mays L. ) and weeds to preemergence herbicide applications and two different crop row spacings. Corn was sown in 76 and 38 cm rows in a field with more than 10 yr of previous no-till crop production. The experimental design was a randomized complete block with four treatment replicates. Treatments consisted of atrazine in combination with one or two of the following herbicides: metolachlor, imazamethabenz, primisulfuron, nicosulfuron, quinclorac or V53482. Herbicides were applied to soil surfaces 80 to 90% covered by mowed debris of the previous crop residue. A boom sprayer was used to apply herbicides in water at a final volume of 374 L $ha^{-1}$. Weed covers were visually estimated in the fall of 1991 and 1992. Average weed cover in the 38 cm rows was 18% for both 1991 and 1992. In 1991 and 1992, weed covers were 41 and 38%, respectively, in the 76 cm rows. The most frequently observed weed in all treatments was ivyleaf morningglory ( Ipomoea hederacea L. Jacq. ), which averaged 14 and 8% in 76 and 38 cm rows, respectively, across all treatments and both years. Perennial weeds included horsenettle ( Solanum carolinense L. ) and hemp dogbane ( Apocynum cannabinum L. ), which occurred in random patterns regardless of treatments. Other annual weeds found in most treatments and row spacings included fall panicum ( Panicum dichotomiflorum Michx. ), giant green foxtail [ Setaria viridis var. major ( Gaudin ) Pospichel ], and smooth pigweed ( Amaranthus hybridus L. ). Corn grain yields in the 76 cm rows ranged from 3090 to 8090 kg $ha^{-1}$ and from 3890 to 8650 kg $ha^{-1}$ in the 38 cm rows, across both years.

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[1]Research Agronomist and Weed Scientist, respectively, USDA, ARS, Beltsville and Frederick, MD.

# OPTIMUM TIME OF CULTIVATION FOR WEED CONTROL IN CORN

Jane Mt. Pleasant[1], Robert Burt and James Frisch

## ABSTRACT

Integrating chemical and mechanical practices has provided acceptable weed control for corn in NY. A field experiment was initiated at the Musgrave Research Farm in Aurora, NY in 1992 to determine if timing of a single cultivation affected weed levels when relying on cultivation alone or in treatments using a combination of mechanical and chemical practices.

Experimental design was an RCB in a split-plot arrangement. Main plot treatments consisted of: 1) broadcast herbicide plus cultivation (BCAST + CULT); 2) band herbicide plus cultivation (BAND + CULT); and 3) cultivation only (CULT ONLY). Sub-plots were time of cultivation based on stage of corn development: 2, 4, 6, and 8 leaf stages. In addition treatments with broadcast herbicide only (BCAST ONLY) and no weed control (NO CONTROL) were also included. Broadcast herbicide treatments used atrazine at 1.12 kg ai/ha and pendimethalin at 1.68 kg ai/ha. Similar rates were applied in a ten-inch band over the corn row for the band treatment. Weed counts were taken approximately 5-7 days after each cultivation. Weed cover was measured in mid-August.

The weed population consisted almost entirely of green and yellow foxtail (Setaria spp). Weed counts taken after the last cultivation showed a significant effect of weed control practice. Weed counts were lowest in BCAST + CULT (69 plants/m$^2$). Weed numbers were significantly higher in BAND + CULT (135 plants/m$^2$) and CULT ONLY (156 plants/m$^2$). There was no effect of time of cultivation nor was there an interaction between weed control practice and time of cultivation.

Percent cover by grassy weeds measured in August was highest in CULT ONLY (57%) and lower in BCAST + CULT (23%) and BAND + CULT (38%). There was no effect of time of cultivation nor was there an interaction. However, time of cultivation did affect in-row weed cover. Grassy weed cover was higher (22%) at the eight-leaf stage compared to the earlier cultivation times. In-row grass cover ranged from 16-17% for the 2,4, and 6 leaf stages. There was no interaction between weed control practice and time of cultivation.

# POSTEMERGENCE APPROACHES TO WEED MANAGEMENT IN CORN

J. A. Ackley, H. P. Wilson, T. E. Hines and B. S. Manley[1]

## ABSTRACT

Field studies were conducted in 1991 and 1992 to evaluate several sulfonylurea herbicides for weed control in corn (Zea mays L. 'Pioneer 3140'). Herbicides were applied alone and in certain combinations with each other or with 2,4-D and dicamba. Studies were conducted on a State sandy loam soil (Typic Hapladults) near Painter, Va. A randomized complete block design with three replications was used for all studies. Herbicides were applied with a tractor-mounted plot sprayer delivering 26 gpa at 30 psi air pressure. Most herbicides were applied postemergence although MON 12041 (Battalion) was applied preemergence at 0.065 and 0.075 lb ai/A.

Control of common lambsquarters (Chenopodium album L.), common ragweed (Ambrosia artemisiifolia L.) and jimsonweed (Datura stramonium L.) approached or exceeded 90% from MON 12041. Slight early corn discoloration occurred although MON 12041 contained the protectant MON 13900; corn recovery was complete within four weeks after emergence. MON 12037 (Permit) contained the same active ingredients as MON 12041 but was applied postemergence at 0.016 and 0.032 lb/A with 0.25% v/v surfactant. Postemergence MON 12037 applications were less effective against common lambsquarters than preemergence MON 12041 applications; neither application adequately controlled morningglory species (Ipomoea spp.). Primisulfuron (Beacon) performance was similar to that of MON 12037 with the exception that control of common lambsquarters with 0.018 lb ai/A was higher from primisulfuron. Nicosulfuron (Accent) was least active against common lambsquarters and common ragweed at the labeled rate of 0.031 lb ai/A. Combinations of nicosulfuron with either primisulfuron or MON 12037 controlled common lambsquarters and common ragweed effectively but did not adequately control annual morningglories. Combinations of these sulfonylurea herbicides with 2,4-D and dicamba (Banvel) were effective against the broadleaf species found in these studies but control was not always superior to that obtained with the component growth regulator herbicides alone.

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# Wirestem muhly (Muhlenbergia frondosa (Poir) Fern.) Management in No-Till Corn

V. K. Nandula and W. S. Curran[1]

## ABSTRACT

Wirestem muhly is a warm season perennial grass that can severily limit the production of corn. Nicosulfuron and primisulfuron, belonging to the sulfonylurea herbicide family, appear to be active on several perennial grasses. Although, previous research with these two herbicides on wirestem muhly suggested some promising results, their effectiveness remains uncertain. This abstract addresses some of the research done at Penn State University with nicosulfuron and primisulfuron on wirestem muhly.

In 1992, two different field experiments, one dealing with herbicide timing and rate and the other, an adjuvant study, were conducted in two locations with established wirestem muhly populations. In the herbicide timing and rate study, a preplant application of glyphosate and postemergence applications of nicosulfuron and primisulfuron at half (1/2X), full (1X), and split (1/2X + 1/2X) rates were included. Single application timings were made at three different growth stages about 10 days apart. In the adjuvant study, four different adjuvants, including nonionic surfactant (NIS), crop oil concentrate (COC), crop oil concentrate + urea ammonium nitrate (UAN), and methylated sunflower oil (Scoil) were compared. Nicosulfuron and primisulfuron were applied at half and full rates with each additive. All treatments in the adjuvant study were applied when wirestem muhly was 10-12 inches tall.

Nicosulfuron gave consistently better wirestem muhly control compared to both primisulfuron and glyphosate. Glyphosate was ineffective in killing wirestem muhly. Generally, the full rates of nicosulfuron (0.5 oz a.i.) and primisulfuron (0.57 oz a.i.) were better than the half rates. In general, control of wirestem muhly obtained with either herbicide was inadequate. The early application timing (wirestem muhly - 6-8") was initially the most effective, but, by the end of the season, the third and last application timing (wirestem muhly - 16") gave the best suppression of wirestem muhly. The second timing (wirestem muhly - 10-12") was always least effective. Split applications (1/2X + 1/2X) applied at the first and third timing were equivalent or better than single applications at the full rate. By the end of season, split and third application timings did not differ from one another. Wirestem muhly biomass was lowest in the split followed by third, second, and first timings. Although, the last application timing was fairly effective in suppressing wirestem muhly, the damage from early season competition reduced corn growth. None of the herbicides or timings provided greater than 78% control by seasons end.

In the adjuvant study, nicosulfuron gave better wirestem muhly control than primisulfuron (average: 76% vs. 54%). The full rates of the herbicides were more effective than the half rates. Scoil was the most effective additive followed by COC + UAN, COC, and NIS. There was a significant interaction between herbicide and adjuvant due to the increased level of control observed by nicosulfuron plus Scoil and the lack of differences between primisulfuron plus any adjuvant.

In conclusion, none of the treatments tested provided excellent control of wirestem muhly. However, for suppression, both application timing and herbicide appeared to be very important. Nicosulfuron gave better control than primisulfuron and the full rate was consistently more effective than the half rate. Among the adjuvants, Scoil appears to be the most effective, while nonionic surfactant the least effective.

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# Activity of Nicosulfuron and Primisulfuron on Pokeweed

M. Marcelli and S. Glenn[1]

## ABSTRACT

Pokeweed (Phytolacca americana L.) control in no-tillage corn was evaluated in 1992. Pokeweed (12 inches high) was treated with 0.031 lbs/A nicosulfuron or 0.036 lbs/A primisulfuron alone or in combination with 0.5 lbs/A 2,4-D or 0.25 lbs/A dicamba. All treatments contained 0.25% (by vol) X-77. Pokeweed control with nicosulfuron and primisulfuron was similar 6 weeks after treatment (WAT) (77 and 72%, respectively). Pokeweed control following tank mixtures of nicosulfuron with 2,4-D (93%) or dicamba (88%); or primisulfuron with 2,4-D (90%) or dicamba (87%) was greater than the control obtained with nicosulfuron or primisulfuron applied alone. In a separate study, 0.018 lbs/A primisulfuron or 0.031 lbs/A nicosulfuron were applied alone or in combination with 0.25 lbs/A 2,4-D or 0.13 lbs/A dicamba to 18- to 24- inch high pokeweed. Nicosulfuron and primisulfuron provided 72 and 60% pokeweed control, respectively. Pokeweed control following tank mixtures of primisulfuron with 2,4-D (75%) and dicamba (80%) was greater than the control obtained with primisulfuron applied alone. Pokeweed control following applications of nicosulfuron combinations with 2,4-D or dicamba was 85 and 80%, respectively. Applications of 0.25 lbs/A 2,4-D or 0.13 lbs/A dicamba alone gave 67 and 68% pokeweed control. Nicosulfuron and primisulfuron have similar activity on pokeweed. Control of pokeweed is improved when these chemicals are tank mixed with 2,4-D or dicamba.

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# The Effect of Tillage and Herbicide on Quackgrass Control in Corn

E.L. Werner and W.S. Curran[1]

## ABSTRACT

Since 1988 nicosulfuron and primisulfuron have been evaluated for quackgrass (Elytrigia repens (L.) Nevski) control at Penn State University. Initial research examined preplant treatments of the two herbicides in no-till corn. Preplant applications can provide good quackgrass control, but corn injury proved to be a concern.

Quackgrass control research at Penn State now focuses on single and split postemergence applications of nicosulfuron and primisulfuron in no-till and reduced-till corn. These treatments were compared to early preplant glyphosate treatments or an early preplant treatment of atrazine followed by a preemergence treatment of simazine. All herbicides were compared in no-till and reduced tillage systems. The tillage treatments were performed with a tandem disk followed by a finishing disk 10 days after glyphosate application. Alachlor and cyanazine were each applied at 2 lb a.i./A plus 2,4-D at 0.5 lb a.i./A preemergence over the entire study.

In 1991, quackgrass control in corn was significantly affected by both tillage and herbicide. Compared to reduced-till, the level of quackgrass control was less in no-till. Early season evaluations indicated that glyphosate and atrazine + simazine were more effective at suppressing quackgrass especially under no-till conditions. The 0.5 lb a.i./A rate of glyphosate was less effective than the 1.0 lb a.i./A rate, especially in no-till. Quackgrass biomass taken early season was significantly higher in the nicosulfuron and primisulfuron plots as compared to the glyphosate and atrazine + simazine plots, especially in no-till. Biomass samples taken mid-season indicated that quackgrass control from all herbicide treatments was similar, although samples taken from the primisulfuron treated plots were slightly higher. Split applications of both postemergence products were superior to either the single high or low rate and nicosulfuron was slightly better than primisulfuron, especially in no-till. Corn yields in no-till were significantly less than reduced-till. Control with all herbicides was adequate enough to overcome any reduction in yield.

Similar results were seen in 1992, however, the effect of tillage was more variable. In general, quackgrass control was the same or superior in the tilled plots compared to the no-till plots. As in 1991, glyphosate and atrazine + simazine provided best control early season, but by late season, levels of control were similar for the four different herbicides. The rate of glyphosate was less important in 1992, with both the 0.5 lb a.i./A rate and 1.0 lb a.i./A rate providing good control, especially in the reduced-till plots. Nicosulfuron was once again superior to primisulfuron, especially in the no-till plots and the split and full labeled rate applications were once again better than the reduced rate.

Atrazine + simazine is a high residual program that although is effective, carries some environmental and management limitations. Even at the 0.5 lb a.i./A rate glyphosate was an adequate treatment. In 1991, there was a significant difference between the 1.0 lb a.i./A rate and 0.5 lb a.i./A rate of glyphosate probably caused by drought stress brought on by an overall drier than normal season. In a year of adequate moisture as in 1992, the two rates are comparable. Tillage following application did not enhance the level of control. Both nicosulfuron and primisulfuron performance were greater in reduced-till than no-till. Split applications in general were better than any one full or reduced rate. Nicosulfuron appeared more active than primisulfuron on quackgrass, especially in no-till or when applied at reduced rates.

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# Johnsongrass (Sorghum halepense) (L.) Pers. Control in Corn

J.E. Rowehl and W.S. Curran [1]

## Abstract

Johnsongrass (Sorghum halepense) (L.) Pers. is considered one of the major weed control challenges in corn in southern Pennsylvania. Nicosulfuron (Accent) and primisulfuron (Beacon) are two recently introduced post-emergence herbicide products available to control this weed. To learn more how these products perform under various conditions, two different field trials were conducted in 1991 and 1992 in York County, PA. These studies were intended to indicate what a farmer might expect to happen if a) the products are applied at different weed growth stages , b) split applications were used, c) lower than standard rates were used, or d) a combination of the products were used.

Treatments in 1991 compared the effects of using half versus the full label rate of product at both the recommended stage of weed growth (8-18") and at a later application (18-30") time, as well as the full rate split between both times. Crop oil concentrate was included in each treatment. The trial was done in a cooperating farmer's field that was chisel plowed and disked. In 1992 the same field was used however the planting was done with no tillage. Application of the full rate of each product was compared to two thirds the rate as well as a combined half rate of each product, all applied at the recommended weed growth stage (6-15"). Crop oil concentrate and UAN solution were included in each treatment.

Growing conditions in 1991 were poor. There was negligible rain after May 10 with above normal temperatures. Plants were under stress before, during, and after application. Results show that the performance of nicosulfuron and primisulfuron did not differ significantly when averaged over rates and timings, although ratings of nicosulfuron were generally higher, particularly later in the season . Application rate was more important with nicosulfuron than primisulfuron. Applications at the recommended growth stage gave better control than later applications at both rates. The split application of nicosulfuron gave the best control although the full rate at the first application was nearly as good.

In 1992 rainfall was below average but adequate. Temperature was below normal. Growth of the Johnsongrass from rhizomes was well ahead of the corn. Early season (28 days post application) control ratings showed no differences in control between all treatments. Later season ratings (54 days post application) showed the percent control provided by nicosulfuron was maintained and was significantly better than primisulfuron at all rates. Reduced rates provided comparable control to the full rates. Combining half rates of both products provided the greatest control but not significantly higher than nicosulfuron alone. Overall, control was better in 1992 than 1991.

Based on the results of these studies, application rates should not be reduced when growing conditions are hot and dry, particularly when applied beyond optimum growth stage. Reducing rates to two thirds may provide control comparable to the full rate when applied at the optimum time and under good growing conditions. Split applications provide slightly better control but probably not enough to justify a second trip across the field.

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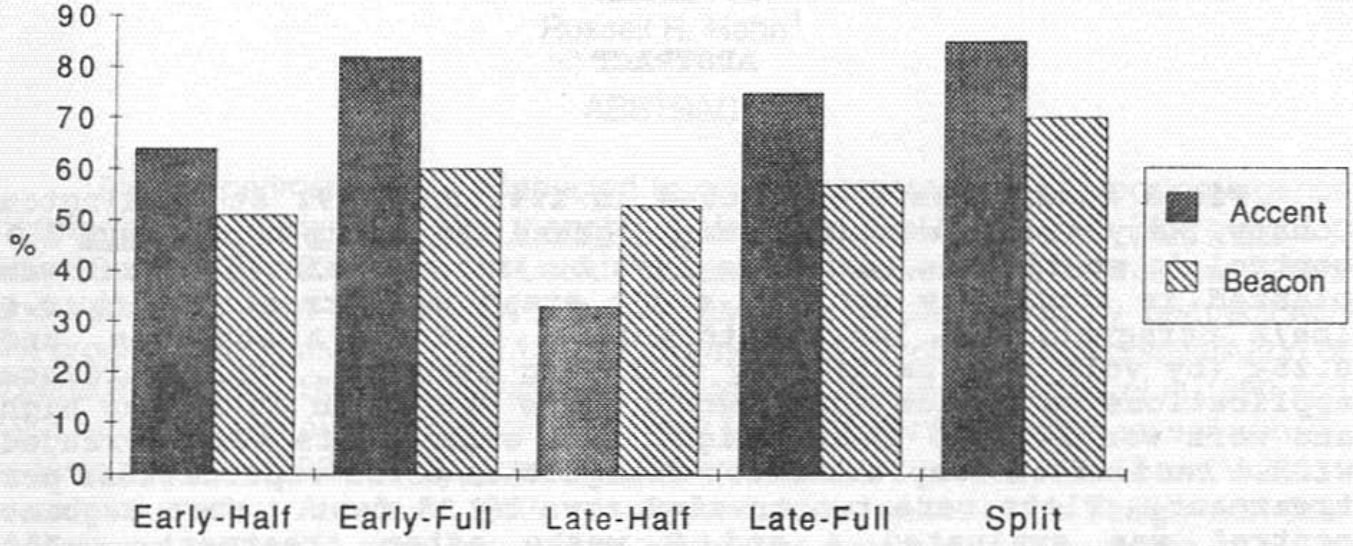
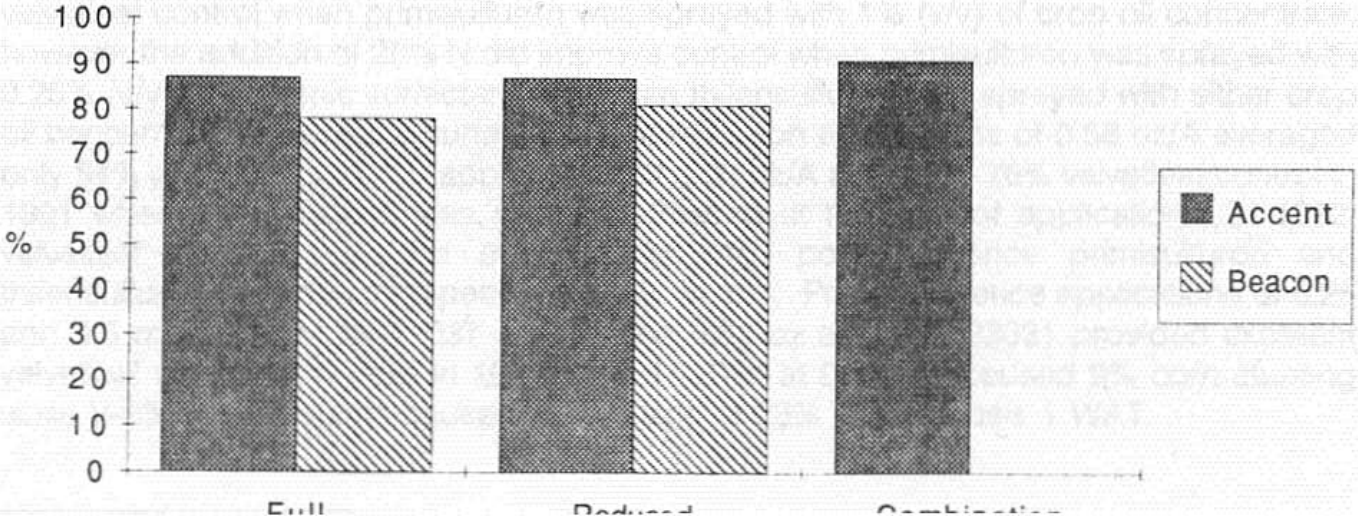
[1] County Agricultural Agent, York County, PA and Assistant Professor of Weed Science, Penn State University respectively.

**Aug 6, 1991 Control Ratings**




**July 21, 1992 Control Ratings**



# HEMP DOGBANE CONTROL WITH SULFONYLUREA HERBICIDES

S. Glenn[1]

## ABSTRACT

Field studies were conducted in 1991 and 1992 at Washington County, Maryland to evaluate hemp dogbane (Apocynum cannabinum L.) control in no-tillage corn (Zea mays L. 'Pioneer 3352'). Corn was planted in early May and all study areas were treated with 0.5 lbs/A paraquat, 2.0 lbs/A metolachlor, 1.6 lbs/A atrazine, and 0.25% (by vol) X-77 mmediately following planting. Postemergence applications were made when hemp dogbane was 10 to 15 inches high and corn was 7 to 10 inches high. All experiments were arranged with a randomized complete block design with three replications per treatment. Plots were two treated rows by 35 feet. Hemp dogbane control was evaluated 4 and 8 weeks after treatment. All treatments containing nicosulfuron or primisulfuron included 0.25% X-77. Postemergence applications of 0.031 lbs/A nicosulfuron, 0.024 and 0.036 lbs/A primisulfuron provided 64, 32, and 39% hemp dogbane control, respectively. Hemp dogbane control following tank mixtures of 0.25 or 0.5 lbs/A 2,4-D (85 and 87%) with nicosulfuron was greater than that obtained with nicosulfuron or 2,4-D (0.5 lbs/A) applied alone. All tank mixtures of 2,4-D (0.25 or 0.5 lbs/A) or dicamba (0.13 or 0.25 lbs/A) with 0.024 or 0.036 lbs/A primisulfuron increased hemp dogbane control compared to that obtained with each herbicide applied alone. Hemp dogbane control with primisulfuron combinations ranged from 59 to 84%. Tank mixtures of nicosulfuron or primisulfuron with 2,4-D or dicamba can effectively control hemp dogbane in no-tillage corn.

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# PRE- AND POSTEMERGENCE VELVETLEAF CONTROL IN FIELD CORN

Russell R. Hahn[1]

## ABSTRACT

Field experiments were conducted to evaluate several pre- and postemergence herbicides for velvetleaf (Abutilon theophrasti Medik.) control in field corn (Zea mays L.). DE-498 and MON-12041 were evaluated for preemergence velvetleaf control near Aurora and Valatie, NY on a silt loam soil with 5% organic matter and a gravelly loam soil with 4% organic matter respectively in 1992. Postemergence applications of primisulfuron or thifensulfuron with different adjuvants were evaluated for velvetleaf control in 1990 and 1991 at Valatie and Aurora respectively, and at Mt. Morris, NY on a silt loam soil with 7% organic matter in 1992. Finally, postemergence applications of MON-12037 and V-23031 were evaluated at Aurora in 1992. A randomized complete-block design with four replications was use in each experiment. Herbicides were applied in water to 10 by 25 or 10 by 27 ft plots using 80015 flat spray tips mounted on a compressed- air bicycle sprayer calibrated to deliver 25 gpa of spray solution.

Preemergence applications of DE-498 at 0.84 and 0.95 oz ai/A caused an average of 21% corn injury 4 weeks after treatment (WAT) at Valatie, while preemergence applications of MON-12041 at 1 oz ai/A caused an average of 43% corn injury 4 WAT. At Aurora, where MON-12041 was applied at 1.2 oz/A, corn injury averaged 11 and 36% for the DE-498 and MON-12041 treatments respectively 4 WAT. When applied in combination with 2.0 lb ai/A of metolachlor, DE-498 and MON-12041 treatments provided a minimum of 97% velvetleaf control 4 and 8 WAT at Valatie. Combinations of DE-498 or MON-12041 with metolachlor controlled 100 and 93% of the velvetleaf 7 WAT at Aurora. Velvetleaf control was 86% when 1.2 oz/A of MON-12041 was applied alone.

Postemergence applications of 0.58 oz ai/A of primisulfuron averaged 97% velvetleaf control while those of 0.06 oz ai/A of thifensulfuron averaged 87% velvetleaf control in 1990. The addition of 4% (v/v) of 28% N to the spray solution did not affect velvetleaf control when primisulfuron was sprayed with 1% (v/v) of crop oil concentrate, however the addition of 28% N did improve control when primisulfuron was sprayed with 0.25% (v/v) of nonionic surfactant and when thifensulfuron was sprayed with either crop oil concentrate or nonionic surfactant. Primisulfuron applications of 0.58 oz/A averaged only 54% and thifensulfuron applications of 0.06 oz/A averaged 76% velvetleaf control in 1991 when the velvetleaf was drought stressed at the time of application. In 1992, velvetleaf control averaged 96 and 99% for postemergence primisulfuron and thifensulfuron treatments respectively at Mt. Morris. Postemergence applications of 0.25 and 0.5 oz ai/A of MON-12037 or 0.42 and 0.63 oz ai/A of V-23031 provided excellent velvetleaf control at Aurora in 1992. MON-12037 at 0.5 oz/A caused 9% corn stunting while V-23031 treatments caused an average of 23% leaf necrosis 1 WAT.

# IMIDAZOLINONE COMBINATIONS FOR POSTEMERGENCE WEED CONTROL IN SOYBEANS

B. S. Manley, H. P. Wilson, and T. E. Hines [1]

## ABSTRACT

Field studies were conducted in 1992 to evaluate imazaquin and imazethapyr alone and in different tankmixes for postemergence broadleaf weed control in soybeans [Glycine max (L). Merr., 'Hutcheson']. Both studies utilized a randomized complete block design with three replications, and were located at the Eastern Shore Agricultural Experiment Station in Painter, Va. Treatments were applied with a tractor-mounted plot sprayer delivering 26 gpa at a pressure of 30 psi.

Treatments in one study included imazethapyr and lactofen alone at rates of 0.063 and 0.2 lb ai/A, respectively. The same rate of imazethapyr was also mixed with lactofen at rates ranging from 0.063 to 0.125 lb/A, imazaquin at 0.024 lb ai/A, and thifensulfuron at 0.002 and 0.004 lb ai/A. A non-ionic surfactant and 30% liquid nitrogen were added at 0.25% v/v and 2.5% v/v, respectively, to all treatments except lactofen applied alone; crop oil concentrate was added at 1.00% v/v to this treatment. Treatments in the second study included imazaquin at 0.063 lb/A, fomesafen alone and mixed with imazaquin (0.063 lb/A) at rates from 0.125 to 0.25 lb ai/A, lactofen alone and combined with imazaquin (0.063 lb/A) at rates from 0.1 to 0.2 lb/A, and imazaquin plus acifluorfen (Scepter O.T.®) at 0.31 lb ai/A and thifensulfuron at rates of 0.002 and 0.004 lb/A mixed with imazaquin (0.063 lb/A). A non-ionic surfactant was added to all treatments in this study.

Thifensulfuron was required with both imazaquin and imazethapyr for 90% control of common lambsquarters (Chenopodium album L.); however, imazethapyr alone and in combination with imazaquin, and imazaquin plus acifluorfen provided partial common lambsquarters control. Lactofen, alone and in combination with imazaquin or imazethapyr, and fomesafen, alone and in combination with imazaquin, provided better control of common ragweed (Ambrosia artemisiifolia L.) than did the other treatments in their respective studies. All treatments that included imazaquin, except imazaquin plus acifluorfen, provided season-long control of common cocklebur (Xanthium strumarium L.). In one study, lactofen (alone and combined with imazaquin) provided excellent (95%) control of common cocklebur; but in the other study, when applied alone or in combination with imazethapyr, it provided less than 90% control. Common cocklebur control with fomesafen alone was dependent on rate. It can be concluded that these weed species respond similarly to imazaquin and imazethapyr, and that neither herbicide can be used alone for broad-spectrum, postemergence annual broadleaf weed control.

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# REDUCED HERBICIDE RATE INTENSIVE MANAGEMENT SYSTEMS FOR SOYBEANS

**Charles W. Swann[1]**

## ABSTRACT

Reduced herbicide rate intensive management weed control systems have potential for use in soybean [Glycine max (L.) Merr] production. These systems generally consist of a soil-applied herbicide treatment (1/2 to 2/3 label rate) followed with a sequential postemergence herbicide treatment (1/2 to 2/3 label rate). Advantages promoted for these systems include reduced weed control costs, reduced pesticide usage and reduction of carry-over potential. Disadvantages may include reduced flexibility in timing of postemergence applications, potential failure of weed control under marginal weather conditions and requirement for cultivation under many conditions.

In 1991 and 1992 pendimethalin + imazaquin was applied as reduced rate (0.5 + 0.063 lb ai/A) and full rate (0.75 + 0.125 lb ai/A) soil-incorporated treatments. The soil-applied treatments were evaluated as single treatments and with sequential postemergence treatments of acifluorfen + bentazon at 0.5X, 0.66X and 1X (0.125 + 0.25, 0.165 + 0.33 and 0.25 + 0.5 lb ai/A) rates. Postemergence treatments were applied at 6 DAE (days after weed emergence), 12 DAE, 18 DAE and 24 DAE. To improve control of morningglory species, 2,4-DB (0.031 lb ai/A) was tank mixed with all postemergence herbicide treatments.

Weed species present were common lambsquarters (Chenopodium album L.), redroot pigweed (Amaranthus retroflexus L.), morningglory (Ipomoea sp.), fall panicum (Panicum dichotomiflorum Michx.) and goosegrass [Eleusine indica (L.) Gaertn.].

In 1991 and 1992, common lambsquarters, redroot pigweed, and fall panicum were satisfactorily controlled with both the reduced rate and full rate soil-incorporated treatments alone. In 1991, morningglory control was generally better with postemergence treatments applied at 24 DAE regardless of rate than with earlier application and, morningglory control was significantly improved when postemergence acifluorfen bentazon treatments were applied over the reduced rate PPI treatment relative to that obtained with the reduced rate PPI treatment used alone.

In 1991, postemergence applications of acifluorfen + bentazon (regardless of rate), at 18 and 24 DAE, applied over the reduced rate PPI treatment, significantly increased soybean yield relative to the reduced rate PPI treatment used alone.

In 1991, yield of soybeans from plots receiving the full rate PPI treatment and postemergence herbicide applications did not differ from plots receiving the full rate PPI treatment alone.

In 1991, reduced rate herbicide input systems provided satisfactory weed control, but generally did not provide a significant improvement in economic return relative to full rate systems. In 1992, excellent control of all weed species was obtained with all weed management systems.

# SOYBEAN RESPONSE TO CHLORIMURON/LINURON COMBINATIONS

E. P. Prostko and B. A. Majek[1]

## ABSTRACT

A field study was conducted in 1992 to evaluate the response of soybeans [Glycine max (L.) Merr. 'Flyer'] to preemergence applications of pre-packaged chlorimuron/linuron (GEMINI 60DF). Rates ranging from 0.6x to 2.3x of the labeled rate (14 oz of product/A; 0.04 lb a.i. chlorimuron + 0.49 lb a.i. linuron) were applied to soybeans planted in a sandy loam soil with 0.53% organic matter. Metolachlor was applied to the entire plot area. All plots, except the untreated check plots, were hand-weeded to eliminate the effects of any uncontrolled weeds. Five inches of rainfall occurred 8 days after the herbicides were applied. None of the rates evaluated had an effect on soybean emergence, pods/plant, or test weight. At 4 weeks after treatment, soybean heights were significantly reduced by all rates of chlorimuron/linuron but at 19 weeks, no differences in height were observed. Only the 1.7x rate (24 oz of product/A; 0.07 lb a.i. chlorimuron + 0.83 lb a.i. linuron) caused a significant yield reduction.

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# FIRST YEAR EXPERIENCES WITH MON-13200 IN MARYLAND

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## ABSTRACT

MON-13200 is a new herbicide under development by the Monsanto Company. The primary focus of this product seems to lie in its prreemergence activity on annual grasses and some annual broadleaf weed species. This product was field tested in Maryland in 1992, examining its potential activity in corn (Zea mays L.), soybeans [Glycine max (L.) Merr.], and alfalfa (Medicago sativa L.).

In corn, good (80-100%) season-long control of triazine-resistant (TR) giant foxtail (Setaria faberi Herrm.), triazine-susceptible (TS) giant foxtail, and large crabgrass [Digitaria sanguinalis (L.) Scop.] was obtained at 0.25 lb ai/A. However, depending upon location and tillage practice, an unacceptable level (>30%) of corn injury was obtained. Injury manifested itself in the form of shortened, chlorotic plants. Injury was observed early in the season and continued to express itself in corn plants through the mid-season (July) ratings.

In full-season no-till soybeans, MON-13200 provided good season-long control of TS giant foxtail when applied as a split application (0.25 lb ai/A early preplant + 0.25 lb ai/A at planting), or as a single application (0.5 lb ai/A) applied at planting. In full-season conventional plantings of soybeans, good season-long control of TS giant foxtail and common lambsquarters (Chenopodium album L.) was obtained at 0.25 or 0.5 lb ai/A. While no soybean injury was observed in the no-till planting, injury was observed in the conventional study.

In alfalfa, applications were made after the first cutting. Rates tested were as follows: 0.25, 0.5, 0.75, and 1.0 lb ai/A. Good season-long control of large crabgrass was obtained at rates of 0.5 lb ai/A or higher. Some injury to the alfalfa was observed, but it did not seem to affect yield of subsequent cuttings.

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# WEED CONTROL AND SOYBEAN TOLERANCE TO SAN 582H.

G. G. Thomas[1]

## ABSTRACT

SAN 582H is a unique thiophene-based, chloroacetamide herbicide discovered by Sandoz Agro Ltd. in Basel, Switzerland. Mode of action studies show that SAN 582H enters target plants primarily through coleoptiles or emerging shoots, and controls weeds by reducing cell division and growth. Field tests have demonstrated that SAN 582H is a herbicide which provides consistent high performance weed control across a wide range of environmental conditions.

It has a flexible application timing and soil applied use rates lower than most competitive standards in soybeans (Glycine max L.). Applications in soybeans may be made prior to weed emergence from early preplant to early postemergence. Active ingredient use rates are 0.70 to 1.50 lb ai per acre (0.80 to 1.70 kg $ha^{-1}$ ) dependent on soil type. SAN 582H controls annual grasses (Digitaria spp., Setaria spp., Panicum spp., and Echinochloa crus-galli and others) and controls or suppresses many broadleaf weeds and yellow nutsedge (Cyperus esculentus L.). Tank mixtures or sequential applications of broadleaf herbicides with SAN 582H have provided a complete weed control program and good to excellent crop safety.

SAN 582H 7.5 EC is the primary formulation used in field performance evaluations. In 1992, a large scale experimental use program was initiated to test SAN 582H with growers. A total of 91 trials in 20 states were conducted in soybeans. Growers replaced the grass component of their current herbicide program with SAN 582H at projected use rates for the particular soil type. Growers indicated excellent crop safety in soybeans, as well as favorable weed control compared to their standard program.

# GELS: THE NEXT GENERATION OF PESTICIDE FORMULATIONS

T. E. Vrabel and J. A. Barron[1]

## ABSTRACT

One of the more recent innovations in pesticide packaging is the development of the polyvinyl alcohol-based water-soluble bag (WSB). Made-to-order for dry formulations, the WSB concept offers improved handling safety, reduced waste disposal, and unit-dose convenience. Unfortunately, WSB technology is not particularly compatible with liquid pesticides, particularly those which are water-based.

Rhône-Poulenc has recently developed and evaluated a new alternative to liquid EC formulations that is compatible with WSB systems. Using a patented process, the active compound is formulated as an emulsifiable gel and carefully sealed in a WSB. Currently developed gel formulations are stable at temperatures ranging from -20 to +50$^{o}$C and do not readily leak out of the sealed WSB even when intentionally dropped, punctured, or stepped on at temperature extremes. An additional benefit of the gelling process is the reduction in the need for non-aqueous solvents compared to standard non-aqueous EC-type formulations. Present indications are that the Rhône-Poulenc gelling process is cost-effective and adaptable to most non-aqueous EC pesticides.

In 1992, Rhône-Poulenc evaluated bromoxynil as a 4 lb./gallon gel formulation (BUCTRIL® GEL) at 63 commercial field corn and cereal crop sites under an Experimental Use Permit. Product performance, mixing, and handling were perceived as superior to liquid BUCTRIL® by 8 out of 10 participants in the EUP. Because of the improved handling characteristics, pre-measured convenience, ease of container disposal, and improved safety of the product, 48 out of 52 users said they would prefer the gel versus the liquid. Federal approval of the BUCTRIL® GEL formulation is expected for the 1993 use season. Rhône-Poulenc is also developing gel formulations of BRONATE®, 2,4-D, MCPA, and several other products for use with WSB systems.

# A COMPARISON OF AQUEOUS AND INVERT EMULSION APPLICATIONS FOR BRUSH CONTROL

Arthur E. Gover, Larry J. Kuhns, and David A. Batey[1/]

## ABSTRACT

Aqueous and invert emulsion herbicide applications were compared for brush control as broadcast foliar and broadcast dormant stem treatments. The foliar applications were made July 8, 1991, near the University Park airport. Picloram plus the amine formulation of triclopyr, at 0.31 plus 1.2 lb ai/ac; and metsulfuron methyl plus the ester formulation of triclopyr at 0.031 plus 1.2 lb ai/ac were applied using a Minnesota-Wanner sprayer equipped with a handgun, delivering approximately 33 gal/ac, covering a 10 ft vertical pattern. Aqueous treatments included a spray adjuvant[2/] at 0.25% v/v. Both invert emulsion treatments included a defoamer[3/] at 0.02% v/v. The picloram plus triclopyr invert emulsion treatment included an inverting oil[4/] at 4.9% v/v, and the metsulfuron methyl plus triclopyr treatment included invert oil at 3.1% v/v. Dormant applications were made April 9, 1992, near the University Park airport. Triclopyr ester plus a premix of 2,4-D and 2,4-DP[5/] at 3.0 plus 1.4 and 1.4 lb ae/ac, respectively, was applied as an aqueous treatment at 25 gal/ac, and as an invert emulsion treatment at 38 gal/ac. The aqueous treatment included a spray oil[6/] at 2 gal/ac, and a drift control agent[7/] at 0.75% v/v. The invert treatment included inverting oil at 5.0% v/v. The aqueous treatments were applied with $CO_2$-powered sprayer mounted on a utility vehicle, using a single Spraying Systems OC-40 spray tip treating a 10 ft vertical pattern. The invert treatments were applied with a modified Weed Systems sprayer with a Minnesota-Wanner flash-inverter, mounted on a utility vehicle, using a single Spraying Systems OC-40 spray tip treating a 9 ft vertical pattern. The predominant species in both test areas were black cherry (Prunus serotina Ehrh.), red maple (Acer rubrum L.), red oak (Quercus rubra L.), mockernut hickory (Carya tomentosa Nutt.), sassafras (Sassafras albidum (Nutt.) Nees), and Populus spp. Brush control was rated in the foliar study on August 31, and in the dormant study on August 28, 1992, using a scale of 1 to 7, where '1'=no injury, '5'=complete control of treated branches, '6'=control beyond the treated branches, and '7'=complete control of the plant.

The invert emulsion application of picloram plus triclopyr completely controlled treated branches of black cherry and hickory, and gave control beyond the treated branches on red maple, red oak, flowering dogwood (Cornus florida L.), and American elm (Ulmus americana L.) (Table 1a). The aqueous treatment provided similar control of black cherry, but did not demonstrate as much activity on red maple, as there was no control beyond the treated branches. The aqueous and invert applications of metsulfuron methyl plus triclopyr completely controlled treated branches of red maple, and provided some control beyond treated branches in black cherry. The invert application of this treatment completely controlled red oak.

The dormant applications of triclopyr plus 2,4-D and 2,4-DP caused only a slight thinning of treated branches of black cherry, red maple, and hickory; whether applied as an invert emulsion or aqueous (Table 1b). Both methods of application were effective in controlling treated branches of Populus spp. and sassafras. The aqueous treatment was more effective than the invert on red oak. The invert treatment completely controlled grey dogwood (Cornus racemosa Lam.), and provided partial control of staghorn sumac (Rhus typhina L.).

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2/ / Clean Cut, Arborchem Products, Ft. Washington, PA.

3/ / Dow Corning Antifoam 1430, Dow-Corning, Midland, MI.

4/ / Visko-Rhap RTU, Agrolinz, Inc., Memphis, TN.

5/ / Weedone 170, containing 1.85 lb/gal 2,4-D and 1.85 lb/gal 2,4-DP, Rhone-Poulenc, Research Triangle, NC.

6/ / Hy-Grade, CWC Chemical, Inc., Cloverdale, VA.

7/ / Sta-Put, Nalco Chemical Co., Naperville, IL.

TABLE 1a: Average injury ratings and number of stems for herbicide treatments applied as invert emulsion or aqueous treatments on July 8, 1991. Injury ratings were taken August 31, 1992, using a scale of 1 to 7, where '1'=no injury, '5'=complete control of treated branches, '6'=control beyond the treated branches, and '7'=complete control of the plant.

| | picloram + triclopyr 0.31 + 1.2 lb ai/ac | | | | metsulfuron methyl + triclopyr 0.031 + 1.2 lb ai/ac | | | |
|---|---|---|---|---|---|---|---|---|
| Species | invert | | aqueous | | invert | | aqueous | |
| | ( ---------- average injury rating (number of stems) ---------- ) | | | | | | | |
| black cherry | 5.0 | (9) | 5.1 | (19) | 5.3 | (11) | 5.6 | (10) |
| red maple | 5.6 | (7) | 5.0 | (16) | 5.0 | (2) | 5.0 | (1) |
| red oak | 6.0 | (1) | - - | | - - | | 7.0 | (1) |
| flowering dogwood | 6.0 | (1) | - - | | - - | | - - | |
| American elm | 6.0 | (1) | | | | | | |
| hickory | 5.0 | (1) | | | | | | |

TABLE 1b: Average injury ratings and number of stems for broadcast dormant stem applications made as aqueous and invert emulsion treatments on April 9, 1992. Injury ratings were taken August 28, using a scale of 1 to 7, where '1'=no injury, '5'=complete control of treated branches, '6'=control beyond the treated branches, and '7'=complete control of the plant.

| | triclopyr + 2,4-DP + 2,4-D 3.0 + 1.4 + 1.4 lb ai/ac | | | |
|---|---|---|---|---|
| Species | invert emulsion | | aqueous | |
| | ( ------ average injury ratings (number of stems) ------ ) | | | |
| black cherry | 2.5 | (43) | 2.1 | (33) |
| red oak | 2.0 | (11) | 3.7 | (9) |
| red maple | 2.8 | (10) | 2.0 | (3) |
| Populus spp. | 4.8 | (5) | 5.0 | 2) |
| mockernut hickory | 1.8 | (5) | 2.5 | (2) |
| staghorn sumac | 3.0 | (4) | - - | |
| sassafras | 5.0 | (2) | 4.5 | (2) |
| grey dogwood | 5.0 | (2) | - - | |

# PHILLY FOAMER REVIVES AN OLD SYSTEM FOR LOW VOLUME BRUSH CONTROL

J.W. Orr[1]

## ABSTRACT

Low-volume foliage spraying - what is it? Low-volume foliage spraying is the application of herbicides to brush using less water and higher concentrations of herbicides than in normal foliage spraying. The concept behind low-volume foliage treatments has been around a long time. In high volume foliage spraying, a 1% solution (1 gallon of herbicide per 100 gallons of water) and an average 150 to 250 gallons of mix is used per acre. For low-volume foliage applications, a 5% to 10% mixture (depending on the herbicide) and only 15 to 25 gallons of mix is applied per acre (1). Note - the same amount of herbicide is still needed per acre.

A major problem with low volume foliar treatments is immediate and accurate assessment of coverage. It is very difficult for the applicator to keep track of where he has sprayed when using water or water and blue dye. The Philly Foamer solves the coverage problem by providing timely visual feedback to the applicator. The applicator sees where he has treated and where he has missed. The herbicide is applied in a thick white foam that is clearly visible.

The advantage of this system over existing low-volume foliage applications is that the applicator can SEE what he is treating! The heavy white foam gives far greater drift control and selectivity than mist blowers or flat fan nozzles normally used for low-volume foliage.

Low-volume foliage is best suited to two types of brush conditions. Low Height - usually one year sprouts following hand cutting or mowing. Maximum height 4 to 5 feet, high or low density. Low Density - scattered brush of various heights not greater than 15 feet. You must be able to move around each tree or clump to treat all sides. At 1500 stems per acre, each stem occupies an area of 29 sq. ft. and they are about 5.5 ft. apart.

Using old methods in new ways, with new equipment and special modifications, there is now a system that promises to bring low-volume foliage applications up to the standards of high volume applications.

Low-volume foliage treatment, of any type, is just one part of an integrated management program.

## ACKNOWLEDGEMENT

Special thanks to Paul Johnston, Philadelphia Electric Co., for his assistance and support in the development of the Philly Foam System.

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# USE OF A PHILLIPS GAS GUN TO APPLY MEASURED DOSES OF METSULFURON METHYL TO MULTIFLORA ROSE

Robert R. Hedberg[1]

## ABSTRACT

A field experiment was conducted in an established pasture overrun with multiflora rose (Rosa multiflora)to evaluate three methods of applying metsulfuron methyl. A dilute foliar spray, a concentrated foliar spray and a highly concentrated soil spot treatment were compared.

The experimental design was a randomized complete block with three replications. Each treatment was applied to an individual free standing clump of multiflora. All treatments were applied on July 18 when the multiflora was shortly past bloom.

The dilute foliar spray was at a concentration of one ounce of formulated product (60% ai) per 100 gallons of water. The concentrated foliar spray was at a concentration of one ounce of product per 10 gallons of water. The soil spot application was at a concentration of one ounce of product per two gallons of water. Both foliar applications included non-ionic surfactant at 0.25% v/v; there was no surfactant added to the soil spot treatment. Equal doses of active ingredient were applied to each treatment based on the diameter of the clumps treated.

The dilute spray was applied to runoff over the whole clump using a hand pumped backpack sprayer. The concentrate foliar spray was applied in one measured Z shaped spray swath per two feet clump diameter at points equidistant around the clump. The soil spot treatment was applied underneath the dripline in one measured squirt per two feet diameter at points equidistant around the clump.

Treatments were rated for foliar mortality on August 22 and for flower mortality and absence of mature fruit on November 1. At the early ratings both foliar sprays had resulted in significant foliar necrosis with slightly more effect from the dilute spray. The soil applications had induced obvious chlorosis and very limited necrosis. At the final ratings both foliar applications had caused complete necrosis and absence of any ripened fruit. The soil applications reduced the number of fruit slightly and delayed ripening but significant numbers of mature fruit did develop.

In summary, metsulfuron methyl gave very good control of multiflora rose. Concentrate foliar sprays using a gas gun applicator reduced spray volumes significantly, improved dosage accuracy and were as effective as dilute sprays. Applications to soil produced slow results and may not be as effective over time.

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# VEGETATION CONTROL PROVIDED BY FALL OR SPRING APPLICATIONS OF NON-SELECTIVE HERBICIDES

David A. Batey, Larry J. Kuhns, and Arthur E. Gover[1/]

## ABSTRACT

A total vegetation control study to compare the effectiveness of fall and spring applications of five herbicides was initiated as part of a cooperative project between the Pennsylvania State University and the Pennsylvania Department of Transportation. The experimental design was a randomized complete block with a factorial treatment arrangement and two replications. The herbicide treatments were imazapyr at 0.75 lb ai/ac, sulfometuron methyl at 0.14 lb ai/ac, bromacil at 4.0 lb ai/ac, tebuthiuron at 3.2 lb ai/ac, and diuron at 8.0 lb ai/ac. Fall applications were made September 16, 1991, and spring applications were made April 15, 1992. The treatments were applied to 5 by 50 ft plots along a section of guiderail on Central Road, near New Stanton, PA. Fall treatments were applied with a $CO_2$ pressurized backpack sprayer delivering 11.5 gal/ac at 30 psi using two Spraying Systems OC-02 spray tips mounted inline on a double swivel nozzle body. One spray tip was angled forward, the other to the rear, to provide coverage on both sides of the guiderail posts. Prior to the fall application the predominant species were tall fescue (Festuca arundinacea Schreb.), orchardgrass (Dactylis glomerata L.), Kentucky bluegrass (Poa pratensis L.), quackgrass (Elytrigia repens L.), and crownvetch (Coronilla varia L.). The spring timing treatments were applied with a $CO_2$ pressurized backpack sprayer delivering 17.3 gal/ac at 24 psi using one Spraying Systems OC-08 spray tip. Visual ratings of percent vegetative cover were taken on April 15, 1992, 212 days after treatment (DAT), for fall treatments only; and June 9, 1992, 55 and 267 DAT for spring and fall treatments, respectively. A later season rating was not taken because the area was unfortunately excavated with a grader. Results are reported in Table 1.

At the April 15 rating, plots treated with diuron had significantly more vegetation than plots treated with imazapyr, sulfometuron methyl, and tebuthiuron. Predominant species were the same as those recorded prior to treatment.

On June 9 the predominant species in the test area were smooth brome (Bromus inermis Leyss.), crownvetch, quackgrass, and tall fescue. There was no significant interaction between herbicide treatment and application timing for the June 9 rating. Spring treated plots had significantly less cover on June 9, averaging 20 percent compared to 31 percent for fall treated plots. Plots treated with imazapyr received significantly lower cover ratings than any treatment except sulfometuron methyl. Plots treated with diuron received significantly higher cover ratings than any other treatment. Off-site movement was not observed for any of the treatments. On July 16, a field day was held at the test site where it was observed that the residual control provided by the fall application of imazapyr was failing, and the fall treated imazapyr plots had noticeably more vegetative cover than the spring treated plots. All plots should have been rated again in late summer, but were destroyed by the grading operation before that could be done.

Under the conditions of this study, it appears that a September application of herbicides may be too early to provide control the following growing season, particularly if using imazapyr, as nearly seven months elapse between application and the onset of the growing season. Although the rate of herbicide degradation should be reduced during the winter, enough degradation or movement out of the surface layer of the soil occurs to limit the effectiveness of the treatments. If further investigation into fall treatments is undertaken, later applications should be evaluated, as many perennial herbaceous species are still green in November in this region, and may be susceptible to herbicide applications.

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TABLE 1: Visual ratings of percent living vegetative cover taken on April 15, 1992 for fall applied treatments only, and on June 9, 1992 for both fall and spring applied treatments. Fall treatments were applied September 16, 1991, and spring treatments were applied April 15, 1992.

| Treatment | Application Rate | Vegetative Cover April 15 (n=2) | Vegetative Cover June 9 Mean (n=4) | Vegetative Cover June 9 Fall Applied (n=2) | Vegetative Cover June 9 Spring Applied (n=2) |
|---|---|---|---|---|---|
| | ( lb ai/ac ) | ( % ) | ( % ) | ( % ) | ( % ) |
| imazapyr | 0.75 | 1 | 7 | 9 | 5 |
| sulfometuron methyl | 0.14 | 3 | 12 | 18 | 5 |
| bromacil | 4.0 | 13 | 30 | 33 | 28 |
| tebuthiuron | 3.2 | 8 | 22 | 25 | 18 |
| diuron | 8.0 | 35 | 58 | 70 | 45 |
| Significance Level (P) | | 0.0615 | 0.0020 | 0.7450 | |
| C.V. (%) | | 71 | 49 | 49 | |
| LSD (P=0.10) | | 23 | 20 | n.s. | |

# BASAL BARK HERBICIDE APPLICATIONS TO FOUR BRUSH SPECIES ALONG ROADSIDES

Larry J. Kuhns, Arthur E. Gover, and David A. Batey[1]

## ABSTRACT

On April 10-12, 1991, the 11 herbicide treatments listed in Table 1 were applied in a ring around the base of 10 stems each of red maple (Acer rubrum L.), black birch (Betula lenta L.), and quaking aspen (Populus tremuloides Michx.); and 8 stems each of Virginia pine (Pinus virginiana Mill.). Hy-grade[2] was used as the diluent in seven of the treatments. Rite-Way[3] was used for comparative purposes to the Hy-grade with the Weedone 170 (2,4-D and 2,4-DP)[4] + Access (triclopyr and picloram)[5] combination. Weedone CB (2,4-D and 2,4-DP)[6] and EXP 4167[7] are ready-to-use formulations. The diameter of the stems was measured 12 in above the ground and 2 ml of treatment solution was applied per inch circumference. A hypodermic needle and syringe was used to uniformly apply the exact amount around each stem. Stem diameters for all species ranged from 1-4 in, with most between 1.5 and 2.5 in. In 1991 control of the birch and aspen was rated on Aug. 19; the maple and pine on Sept. 9. In 1992, all species were rated on July 1.

Quaking aspen was totally controlled by all treatments by the first rating period (Table 1). No suckering was observed from any treated stems.

At least seven of the eight treated stems of Virginia pine were killed by all treatments except the EXP 4167 and Weedone CB. They killed 6 and 5 stems, respectively. All treatments containing Banvel 520 (dicamba and 2,4-D)[8] killed all treated pine stems. Weedone 170 + Access diluted in Rite-Way, killed pine stems faster than when diluted in Hy-grade, with seven versus four stems killed, respectively, at the first rating period. By the second rating period almost all stems were killed by both treatments.

All treatments containing Garlon (triclopyr)[9] or Access provided rapid, complete kill of maples. Banvel 520 alone provided poor control of maples. Banvel 520 + Chopper (imazapyr)[10] acted slower, but by the second rating period, provided almost total control. EXP 4167 killed seven stems, but the three that survived showed few

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[2]Hy-Grade is a highly refined petroleum product; CWC Chemical Co.

[3]Rite-Way is a highly refined petroleum product; N.G. Gilbert Corp.

[4]Weedone 170: 1.85 lbs. 2,4-D + 1.85 lbs. 2,4-DP/gal.; Rhone-Poulenc Ag. Co.

[5]Access: 2 lbs. triclopyr + 1 lb. picloram/gal.; DowElanco

[6]Weedone CB: 0.66 lb. 2,4-D + 0.66 lb.2,4-DP/gal; Rhone-Poulenc Ag. Co.

[7]EXP 4167: Rhone-Poulenc Ag. Co.

[8]Banvel 520: 1 lb. dicamba + 1.9 lbs. 2,4-D/gal.; Sandoz Crop Protection Co.

[9]Garlon: 4lbs. triclopyr/gal.; DowElanco

[10]Chopper: 2 lbs. imazapyr/gal.; American Cyanamid Co.

signs of injury the year after treatment. Weedone CB provided poor control of maples, and as with the EXP 4167, trees that survived showed few signs of injury.

All of the treatments killed at least eight of the ten treated black birch, except the EXP 4167. It killed half of the treated stems and caused moderate injury to the others. Banvel 520 at 30%, Banvel 520 + Chopper, EXP 4167, and Weedone CB were the slowest to react and had the most surviving trees at the first rating period.

Garlon 4 alone at 10% provided total control of all treated stems except for one pine. Access alone at 6% provided total control of all but two stems; one birch and one pine, both of which were severely injured. Combining another product with either of these at the rates tested would provide essentially no benefit.

Banvel 520 alone at 50% provided total control of the birch, aspen, and pine; but almost no control of the maple. Control was comparable at 30%, except for two severely injured birch stems which survived. Combining Chopper with Banvel 520 provided excellent control of the maples.

The control provided by Weedone 170 could not be determined because the Access alone provided results comparable to the combinations. Treatments containing the Rite-way diluent killed the pines faster than those containing Hy-grade.

EXP 4167 provided marginal control of all species except the aspen, which was totally controlled. Weedone CB controlled birch and aspen, but did not provide good control of maple or pine.

TABLE 1: The number of stems of four brush species in each injury rating category the year of treatment and the year after treatment with basal bark herbicide. Applications were made April 10 and 12, 1991, to 10 stems each of red maple, black birch, and quaking aspen, and 8 stems of Virginia pine. Injury was rated in August and September, 1991, and July 1, 1992. Injury was rated on a 1 to 5 scale, with '1'=no injury, and '5'=dead. Stems falling into rating categories '1' and '2' are not shown.

| Treatment | | red maple | | | | | | black birch | | | | | | quaking aspen | | | | | | Virginia pine | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1991 | | | 1992 | | | 1991 | | | 1992 | | | 1991 | | | 1992 | | | 1991 | | | 1992 | | |
| Chemical | % v/v | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 |
| | | (stems/category) | | | | | | (stems/category) | | | | | | (stems/category) | | | | | | (stems/category) | | | | | |
| Garlon 4 | 10 | | | 10 | | | 10 | | 1 | 9 | | | 10 | | | 10 | | | 10 | 1 | 1 | 5 | 1 | | 7 |
| HyGrade | 90 | | | | | | | | | | | | | | | | | | | | | | | | |
| Access | 6 | | | 10 | | | 10 | 1 | 2 | 7 | | 1 | 9 | | | 10 | | | 10 | 1 | 1 | 6 | | | 7 |
| HyGrade | 94 | | | | | | | | | | | | | | | | | | | | | | | | |
| Banvel 520 | 30 | 1 | 1 | 2 | | | 2 | 3 | 4 | 2 | | 2 | 8 | | | 10 | | | 10 | 1 | 1 | 6 | | | 8 |
| HyGrade | 70 | | | | | | | | | | | | | | | | | | | | | | | | |
| Banvel 520 | 50 | 4 | 3 | | | | 1 | | 3 | 7 | | | 10 | | | 10 | | | 10 | 1 | 1 | 6 | | | 8 |
| HyGrade | 50 | | | | | | | | | | | | | | | | | | | | | | | | |
| Banvel 520 | 30 | | 1 | 9 | | | 10 | | 1 | 9 | | | 10 | | | 10 | | | 10 | | | 8 | | | 8 |
| Garlon 4 | 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| HyGrade | 60 | | | | | | | | | | | | | | | | | | | | | | | | |
| Banvel 520 | 30 | | | 10 | | | 10 | | 1 | 9 | | 1 | 9 | | | 10 | | | 10 | | | 8 | | | 8 |
| Access | 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| HyGrade | 60 | | | | | | | | | | | | | | | | | | | | | | | | |
| Banvel 520 | 40 | 2 | 2 | 6 | | 1 | 9 | 1 | 3 | 6 | 1 | | 9 | | | 10 | | | 10 | | 1 | 7 | | | 8 |
| Chopper | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| HyGrade | 46 | | | | | | | | | | | | | | | | | | | | | | | | |
| Weedone 170 | 14 | | | 10 | | | 10 | 1 | 1 | 8 | 1 | | 9 | | | 10 | | | 10 | 3 | 1 | 4 | | 1 | 7 |
| Access | 6 | | | | | | | | | | | | | | | | | | | | | | | | |
| HyGrade | 80 | | | | | | | | | | | | | | | | | | | | | | | | |
| Weedone 170 | 14 | | | 10 | | | 10 | 1 | 1 | 8 | 1 | 1 | 8 | | | 10 | | | 10 | | 1 | 7 | | | 8 |
| Access | 6 | | | | | | | | | | | | | | | | | | | | | | | | |
| RiteWay | 80 | | | | | | | | | | | | | | | | | | | | | | | | |
| EXP 4167 | 100 | 1 | | 7 | | | 7 | 6 | 3 | 1 | 4 | 1 | 5 | | | 10 | | | 10 | | 2 | 6 | 2 | | 6 |
| Weedone CB | 100 | 2 | | 2 | | | 3 | 3 | 2 | 5 | | | 10 | | | 10 | | | 10 | 3 | 1 | 4 | 2 | 1 | 5 |

# CONTROL OF ROADSIDE BRUSH USING HERBICIDE INJECTION TREATMENTS

Arthur E. Gover, Larry J. Kuhns, and David A. Batey[1/]

## ABSTRACT

Three brush species were treated with either picloram or triclopyr, using three injection methods designed to reduce herbicide handling and applicator exposure. Five stems each of green ash (Fraxinus pennsylvanica Marsh.), red oak (Quercus rubra L.), and red maple (Acer rubrum L.), were treated with each treatment combination on September 11 and 12, 1991, along Interstate 80, near Bellefonte, PA. Stem diameters ranged from 2 to 10 in, with most in the 4 to 6 in range. Each injection method consisted of an injection unit containing 0.16 g ae of either picloram or triclopyr, which was applied around the stem at a rate of 1 unit per 4 in of stem circumference, measured at 4 ft. The injections were made at a height of 1.5 to 3 ft on the stem. The three injection methods were the 'Wee-Do', which used an impact lance to drive a .22 caliber cartridge containing the herbicide through the bark; 'Gel Cap', which was a plastic cap mounted on a screw, and is driven into the outer bark using an electric drill; and 'F.I.C.', which consists of a hammer-like tool used to remove a plug approximately 0.4 in wide by 1.0 in deep from the tree, and a collapsible plastic capsule which is driven into the hole. Injury ratings were taken July 1, 1992, on a scale of 1 to 5, where '1'=no injury, and '5'=dead stem.

'Gel Cap' was the easiest treatment to apply, but did not seem to penetrate bark well, particularly green ash. The 'Wee-Do' provided the most consistent bark penetration, but the 4 ft lance was cumbersome to use in thick underbrush. The 'F.I.C.' was difficult to use on smaller stems, particularly on the hard-wooded species, and nearby objects interfered with the arm swing necessary to remove the plugs.

No red oaks, regardless of injection method, were injured by triclopyr (Table 1). Triclopyr caused only slight injury in red maple, and only moderately injured a few stems of green ash when applied with the 'Wee-Do'.

The 'Wee-Do' provided the most consistent control among the picloram treatments, causing moderate to severe injury in all species. When picloram was applied with the 'Gel-Cap', green ash was not injured, red oak ranged from no injury to severe injury, and red maple was severely injured with this method. Applied with the 'F.I.C.' picloram caused injury which ranged from , but most treated stems of green ash were not injured.

Several of the treated red maples had codominant stems. When the union of the stems was below the injection site, no injury was observed in the untreated stem, even when the treated stem was killed. There were two observed instances of plants near picloram-treated green ash showing foliar injury, apparently from the herbicide being exuded by the roots of the treated plants.

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TABLE 1: Visual injury ratings for three species treated with picloram or triclopyr, each at 0.16 g ae per 4 in of stem circumference, using three different injection methods. Applications were made September 11 and 12, 1991; and injury ratings taken July 1, 1992, using a scale of 1 to 5, where '1'=no injury, and '5'=dead stem.

| Injection Method | Picloram Injury Rating 1 | 2 | 3 | 4 | 5 | Triclopyr Injury Rating 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| | (number of stems) | | | | | (number of stems) | | | | |
| | | | | | | Red Oak | | | | |
| Wee-Do | | 1 | 2 | 2 | | 4 | | | | |
| Gel Cap | 1 | 2 | 1 | 1 | | 5 | | | | |
| F.I.C. | | | 2 | 2 | 1 | 5 | | | | |
| | | | | | | Red Maple | | | | |
| Wee-Do | | | | 4 | 1 | 2 | 3 | | | |
| Gel Cap | | | | 2 | 3 | 4 | 1 | | | |
| F.I.C. | | 1 | 2 | 1 | 1 | 3 | 2 | | | |
| | | | | | | Green Ash | | | | |
| Wee-Do | | | 4 | 1 | | 2 | 1 | 2 | | |
| Gel Cap | 5 | | | | | 3 | 1 | | | |
| F.I.C. | 3 | 1 | 1 | | | 4 | 1 | | | |

# STUDIES OF FALL FOLIAR HERBICIDE APPLICATIONS FOR CONTROLLING ROADSIDE BRUSH

Arthur E. Gover, Larry J. Kuhns, and David A. Batey[1/]

## ABSTRACT

The Pennsylvania Department of Transportation relies on late season, foliar applied herbicides to provide effective brush control, with a low visual impact, as the herbicides used and the timing of application allows the injury symptoms to blend somewhat with natural fall coloration. The effect of these treatments must be confined to the treated branches of the brush, due to the potential of off-site damage if the herbicides translocate widely through the brush, and damage portions of the plant that may be off the right-of-way. Two studies were initiated in 1991 to evaluate the ability of different herbicide combinations to provide confined brush control.

## MATERIALS AND METHODS

A study comparing four different herbicide combinations including fosamine ammonium (ammonium ethyl carbamoylphosphonate) was established near New Stanton, PA, on August 27, 1991. The treatments included fosamine ammonium at 6.0 lb ai/ac in combination with either imazapyr ((±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylic acid) at 0.062 lb ai/ac, glyphosate (*N*-(phosphonomethyl)glycine) at 1.5 lb ai/ac, the ester formulation of triclopyr ([(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid) at 1.5 lb ai/ac, or metsulfuron methyl (methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino] carbonyl]amino]sulfonyl]benzoate) at 0.038 lb ai/ac. Fosamine ammonium plus imazapyr was applied at two spray volumes, 9 gal/ac and 30 gal/ac. All other treatments were applied in 30 gal/ac. The treatments were applied to 175 ft plots using a $CO_2$-powered sprayer and a Radiarc. The 30 gal/ac treatments were applied to a 13 ft vertical pattern at 30 psi, and the 9 gal/ac treatment was applied to a 15 ft vertical pattern at 30 psi. All treatments included a spray adjuvant[2/] at 0.25% v/v. The most common species were red maple (Acer rubrum L.), red oak (Quercus rubra L.), black cherry (Prunus serotina Ehrh.), green ash (Fraxinus pennsylvanica Marsh.), staghorn sumac (Rhus typhina L.), sassafras (Sassafras albidum Nutt.), flowering dogwood (Cornus florida L.), and multiflora rose (Rosa multiflora Thunb.).

A second study, evaluating fosamine ammonium and triclopyr, alone and in combination was established September 14, 1991, at the Pennsylvania State University, near the University Park Airport. The treatments included triclopyr ester alone at 2.0 and 4.0 lb ai/ac; fosamine ammonium alone at 6.0 lb ai/ac; fosamine ammonium plus triclopyr ester at three rates, 2.0 plus 1.0, 3.0 plus 1.0, and 3.0 plus 2.0 lb ai/ac; and fosamine ammonium plus triclopyr amine at 2.0 plus 1.0 lb ai/ac. These treatments were applied to 150 ft plots with a 13 ft vertical pattern at 30 gal/ac at 30 psi using a $CO_2$-powered sprayer and a Radiarc. The most common species in this study were black cherry and red maple, with smaller amounts of red oak, sassafras, and green ash.

A visual rating of foliar injury was taken at University Park on October 4, 1991, 20 days after treatment (DAT). Brush control was visually rated at New Stanton on July 13, and University Park on August 31, 1992, with each stem rated on a scale of 1 to 7, where '1'= no injury, '5'=complete control of treated branches, '6'=control beyond the treated branches, and '7'=complete control of the plant.

## RESULTS AND DISCUSSION

At New Stanton, fosamine ammonium plus imazpyr provided excellent control of all species at

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both 9 and 30 gal/ac (Table 1). This combination was particularly active on green ash, red maple, red oak, and american elm (Ulmus americana L.), with several 30 ft red maples completely controlled. Moderate understory injury was observed in both of these treatments as a thinning of the original herbaceous cover. Fosamine ammonium plus glyphosate was very active on sassafras, and controlled treated stems of staghorn sumac, red maple, black locust, and multiflora rose. Single stems of tuliptree (Liriodendron tulipifera L.) and flowering dogwood showed only slight injury, and apple (Malus spp) showed severe thinning on treated branches. Branches of sassafras, staghorn sumac,black cherry, American elder (Sambucus canadensis L.), and shingle oak (Quercus imbricaria Michx.) treated with fosamine ammonium plus triclopyr were completely controlled. Red maple and red oak showed severe thinning of branch tips, but treated branches were not completely controlled, and treated branches of green ash were only moderately injured. Fosamine plus metsulfuron methyl was extremely active on multiflora rose, completely controlling all treated plants; and black cherry was controlled well above the treated branches. Sassafras was only slightly injured.

When rated 20 DAT, all treatments caused foliar injury to all species at University Park. Red maple foliage showed necrosis from all treatments. Black cherry was strongly discolored by all treatments, but displayed more necrosis when treated with triclopyr alone than with fosamine ammonium or combination treatments. On August 31, 1992, triclopyr ester alone at 2 lb ai/ac completely controlled treated branches of black cherry, and caused severe injury to treated branches of red maple, but only slightly injured sassafras (Table 2). Increasing triclopyr rate to 4 lb ai/ac improved control of red maple and sassafras, and completely controlled the single red oak present Fosamine ammonium alone at 6 lb ai/ac provided only moderate control of treated branches of black cherry, red maple, and flowering dogwood. The best activity was seen on red oak, green ash, and mockernut hickory (Carya tomentosa Nutt.) which showed severe injury to treated branches, while only slight injury to sassafras was noted. When triclopyr at 1 lb ai/ac was combined with 2 lb ai/ac of fosamine ammonium, the ester formulation was more effective than the amine formulation in the control of black cherry, red maple, red oak, and green ash. Fosamine ammonium plus triclopyr ester at 3 plus 1 lb ai/ac, respectively, effectively controlled treated branches of black cherry, and moderately injured treated branches of red maple and green ash. Increasing the triclopyr rate to 2 lb ai/a improved control of red maple considerably.

The combination of fosamine ammonium and imazapyr was very active on all species treated, perhaps too active. The degree of translocation shown by this treatments at the rates used could lead to off right-of-way damage. This is of particular concern in Pennsylvania, where many of the highway right-of-ways are only 33 ft wide, and much of the brush encroaching on the roadway originates from off the right-of-way. Efforts to refine the rates used in this combination are warranted, as each of the other combinations evaluated exhibited weakness on at least one brush species. Additional studies have been inititiated to evaluate this combination at lower rates to try to maintain the excellent control of treated branches while limiting translocation beyond the treated area.

At University Park, triclopyr ester alone was more effective on the species present than fosamine ammonium alone, and the combination of these two herbicides at 2 plus 3 lb ai/a, respectively, provided control similar to triclopyr alone at 4 lb ai/ac. The combination of these two herbicides does not seem to provide the increase in the control spectrum seen with the combination of fosamine ammonium and imazapyr. Under the conditions of this study, all treatments caused noticeable foliage discoloration 20 DAT, so fosamine ammonium alone or in combination with triclopyr did not provide any advantage over triclopyr alone.

## ACKNOWLEDGEMENTS

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TABLE 1: Average injury rating and number of stems, by species, for foliar herbicide treatments applied August 27, 1991. Injury was rated July 13, 1992, on a scale of 1 to 7, where '1'=no injury, '5'=complete control of treated branches, '6'=control beyond treated branches, and '7'=complete control of the tree.

| | Herbicides (lb ai/ac) | | | | |
|---|---|---|---|---|---|
| Species | fosamine (6.0) imazapyr (0.062) [9 gal/ac] | fosamine (6.0) imazapyr (0.062) | fosamine (6.0) glyphosate (1.5) | fosamine (6.0) triclopyr (1.5) | fosamine (6.0) metsulfuron (0.038) |
| | (---------- average injury rating (number of stems) ----------) | | | | |
| red maple | 6.0 (7) | 5.9 (24) | 5.0 (1) | 4.1 (9) | - - |
| staghorn sumac | 5.0 (1) | 5.0 (8) | 4.9 (11) | 5.0 (6) | - - |
| black cherry | 5.0 (1) | 7.0 (2) | - - | 5.0 (1) | 6.0 (4) |
| sassafras | - - | 5.2 (8) | 5.9 (8) | 5.0 (10) | 2.0 (2) |
| red oak | 5.9 (18) | 7.0 (3) | - - | 4.5 (4) | - - |
| green ash | 6.2 (11) | 6.0 (3) | - - | 3.0 (1) | - - |
| flowering dogwood | 6.0 (3) | 5.5 (4) | 2.0 (1) | - - | - - |
| multiflora rose | - - | - - | 5.0 (1) | 5.0 (3) | 7.0 (10) |
| american elder | 5.0 (1) | - - | - - | 5.0 (1) | - - |
| shingle oak | - - | - - | - - | 5.0 (1) | 5.0 (1) |
| american elm | 6.0 (4) | - - | - - | - - | - - |
| hawthorn | 5.2 (9) | - - | - - | - - | - - |
| hickory | 5.0 (1) | - - | - - | - - | - - |
| black locust | - - | - - | 5.0 (1) | - - | - - |
| apple | - - | - - | 4.0 (1) | - - | - - |
| tuliptree | - - | - - | 2.0 (1) | - - | - - |

BLE 2: Average injury rating and number of stems by species for foliar herbicide treatments applied September 14, 1991. Injury was d August 31, 1992, on a scale of 1 to 7, where '1'=no injury, '5'=complete control of treated branches, '6'=control beyond treated ıches, and '7'=complete of control of the tree.

| cies | Herbicides (lb ai/ac) | | | | | | |
|---|---|---|---|---|---|---|---|
| | triclopyr ester 2.0 | triclopyr ester 4.0 | fosamine 6.0 | fosamine 2.0 triclopyr ester 1.0 | fosamine 2.0 triclopyr amine 1.0 | fosamine 3.0 triclopyr ester 1.0 | fosamine 3.0 triclopyr ester 2.0 |
| | (----------average injury rating (number of stems)----------) | | | | | | |
| :k cherry | 5.0 (9) | 5.0 (9) | 3.2 (11) | 4.8 (9) | 3.4 (9) | 4.8 (13) | 4.9 (21) |
| maple | 4.0 (2) | 5.0 (5) | 3.0 (4) | 3.7 (3) | 3.2 (4) | 3.3 (3) | 4.7 (16) |
| oak | - - | 7.0 (1) | 4.5 (4) | 4.5 (4) | 1.0 (1) | - - | - - |
| :afras | 2.0 (1) | 3.8 (4) | 2.0 (1) | - - | - - | - - | - - |
| :n ash | - - | - - | 4.0 (2) | 2.6 (17) | 2.3 (6) | 3.0 (1) | - - |
| vering dogwood | - - | - - | 3.5 (2) | - - | - - | - - | - - |
| :kernut hickory | - - | - - | 4.0 (1) | - - | 4.0 (1) | - - | - - |
| te oak | - - | - - | - - | 4.8 (4) | - - | - - | - - |
| :rican elder | - - | - - | - - | - - | - - | - - | 5.0 (1) |

# EFFECTIVENESS OF PREEMERGENCE HERBICIDES APPLIED ABOVE, UNDER, OR WITHOUT PINE BARK MULCH

Jeffrey F. Derr[1]

## ABSTRACT

Five plants of marigold (Tagetes patula L.), petunia (Petunia x hybrida Vilm.), and zinnia (Zinnia elegans Jacq.) were planted per plot in a field study. Soil pH was 5.8 with 2.1% organic matter. After transplanting, herbicides were applied either to bare soil, or under or above a two inch depth of shredded pine bark mulch. Granular formulations of metolachlor at 4 lb ai/A, metolachlor plus simazine at 4 plus 1 lb/A, oxadiazon at 3 lb/A, oxyfluorfen plus oryzalin at 2 plus 1 lb/A, trifluralin at 3 lb/A, and napropamide at 4 lb/A were applied, while sprayable formulations of isoxaben at 0.75 lb/A and oryzalin at 3 lb/A were applied.

At four weeks after treatment, oxyfluorfen plus oryzalin applied under mulch injured petunia, marigold, and zinnia less than applications to bare soil. Oxyfluorfen plus oryzalin applied to bare soil reduced stand of petunia. Metolachlor plus simazine applied under mulch reduced stand of all three flowers, while applications made above mulch reduced survival of petunia and marigold, and applications to bare soil reduced stand of petunia and zinnia. Isoxaben applied above mulch reduced zinnia stand. None of the other herbicides affected survival of the three annual flowers. No reduction in petunia, marigold or zinnia growth was noted with any application of metolachlor, oxadiazon, napropamide, or trifluralin eight weeks after treatment. The other herbicides tended to reduce growth of petunia or zinnia with one or more types of application.

Metolachlor and metolachlor plus simazine gave greater reduction in yellow nutsedge (Cyperus esculentus L.) shoot fresh weight 10 weeks after application when applied under mulch (>90% reduction) compared to above mulch (<70% reduction). Metolachlor gave similar yellow nutsedge control when applied either to bare soil or under mulch. All herbicides except oxadiazon and oxyfluorfen plus oryzalin tended to give greater control of yellow foxtail [Setaria glauca (L.) Beauv.] when applied under compared to above mulch. Oxadiazon tended to give greater yellow foxtail control when applied above mulch, while oxyfluorfen plus oryzalin gave similar control when applied either under or above mulch. Pine bark mulch alone gave complete control of prostrate knotweed (Polygonum aviculare L.) and carpetweed (Mollugo verticillata L.).

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# PREMERGENCE HERBICIDES APPLIED UNDER, ABOVE, OR WITHOUT MULCH - THEIR EFFICACY AND EFFECTS ON ANNUAL FLOWERS AND GROUND COVERS

Larry J. Kuhns and Ken Fager[1]

## ABSTRACT

This study was conducted to compare the efficacy of Derby (simazine + metolachlor)[2] at 1.0 + 4.0 lbs ai/ac, Devrinol (napropamide)[3] at 4 lbs ai/ac, Gallery (isoxaben)[4] at 1.0 lb ai/ac, Pennant (metolachlor)[5] at 4 lbs ai/ac, Ronstar (oxadiazon)[6] at 3 lbs ai/ac, Rout (oxyfluorfen + oryzalin)[7] at 2.0 + 1.0 lbs ai/ac, XL (benefin + oryzalin)[8] at 1.5 + 1.5 lbs ai/Aac and Treflan (trifluralin)[9] at 3.0 lbs ai/ac when applied to bare soil, under an organic mulch, or on top of the mulch. The plots were planted to four herbaceous annual flowers: Orbit Violet geranium (Pelargonium X hortorum L.H. Bailey cv. Orbit Violet), Aurora Light Yellow marigold (Tagetes patula L. cv. Aurora Light Yellow), Ultra Plum Petunia (Petunia X hybrida Hort. Vilm.-Andr. cv. Ultra Plum), Pulcino Bronze zinnia (Zinnia elegans Jacq. cv. Pulcino Bronze) and three ground covers: English ivy (Hedera helix L.) common periwinkle (Vinca minor L.) and wintercreeper eunoymus (Euonymus Fortunei Hand.-Mezz.). Plots were 7 ft by 13 ft with 2 ft borders arranged in a randomized complete block design with a factorial treatment arrangement and three replications.The field was plowed and harrowed free of weed seedlings prior to planting the annual flowers and ground covers on May 27 to 29, 1992. On May 29 a 2 inch layer of hardwood bark mulch was applied to those plots receiving herbicide "above" mulch. On May 30 & 31 about 1 inch of rain fell. On June 2 and 3 herbicide treatments were applied, with mulch applied to those treatments receiving herbicide "under" mulch. On June 4-6 an additional one inch of rain fell. Plots were handweeded and the weeds were counted on July 15. Annual flower quality was rated on July 22, groundcover quality on Oct. 29.

The predominant weeds in the plots were hairy galinsoga (Galinsoga ciliata [Raf.] Blake), common purslane (Portulaca oleracea L.), common lambsquarters (Chenopodium album L.), and redroot pigweed (Amaranthus retroflexus L.). Present in lesser amounts were common chickweed (Stellaria media [L.] Cyrillo), shepherdspurse (Capsella bursa-pastoris [L.] Medic.), and a mix of annual grasses, predominantly foxtails (Setaria spp.). Compared to the unmulched control; mulch alone greatly reduced the populations of purslane, redroot pigweed, chickweed, and shepherdspurse; and decreased the number of annual grasses by over 50%. The mulch did not affect the growth of the galinsoga and lambsquarters.

Derby provided almost total weed control regardless of mulch placement. The only weakness was several lambsquarters grew in the herbicide over the mulch plots. Derby with no mulch caused a slight reduction in quality of petunia and marigold; Derby under mulch reduced the quality of ivy and periwinkle.

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[2]Derby: 1% simazine + 4% metolachlor, Ciba-Geigy

[3]Devrinol: 50% napropamide, Stauffer Chem. Co.

[4]Gallery: 75% isoxaben, DowElanco

[5]Pennant: 5% metolachlor, Ciba-Geigy

[6]Ronstar: 2% oxadiazon, Rhone-Poulenc Ag. Co.

[7]Rout: 2% oxyfluorfen + 1% oryzalin, Sierra Chem. Co.

[8]XL: 1% benefin + 1% oryzalin, DowElanco

[9]Treflan: 5% trifluralin, DowElanco

Devrinol was most effective when placed under the mulch. Only a few lambsquarters and galinsoga plants grew in the plots. With no mulch it did not provide any control of galinsoga or lambsquarter, and only 50% control of shepherdspurse. It provided good to excellent control of the other weeds. When placed on top of the mulch, it provided little better weed control than mulch alone. Devrinol did not reduce the quality of any plants except for a slight reduction of marigold quality when it was applied without mulch.

Gallery under mulch provided total weed control. Without mulch it provided excellent control of all weeds. Applied on top of the mulch, it did not control annual grasses, but did greatly reduce the population of all others. Gallery over the mulch had no effect on the quality of any of the plants. When applied with no mulch, it slightly reduced the quality of the marigolds. When applied under the mulch it reduced the quality of the euonymus and periwinkle.

Except for a few surviving lambsquarters, Pennant under mulch provided total weed control. When applied without a mulch, or on top of the mulch, it controlled everything but lambsquarters. Pennant did not reduce the quality of any of the test plants, regardless of placement.

Ronstar without mulch controlled all weeds except galinsoga and chickweed. When applied on top of the mulch, only the galinsoga survived. When applied under the mulch, galinsoga, lambsquarter, and some redroot pigweed were found in the plots. Ronstar without mulch reduced the quality of petunia, marigold, and periwinkle. When applied in combination with a mulch, no plants were injured.

Rout provided total weed control when applied without a mulch. When applied under the mulch it provided excellent control of everything but annual grasses. When on top of the mulch only a few scattered weeds survived. Rout applied without a mulch severely injured all of the plants in the plots. When applied in combination with a mulch, no plants were injured, except the euonymus in the herbicide under the mulch plots.

XL provided almost total weed control when applied without or under the mulch. When on top of the mulch it allowed the growth of some galinsoga and lambsquarter. XL did not reduce the quality of any of the plants.

When applied without a mulch Treflan controlled most of the weeds, but was weak on galinsoga and shepherdspurse. When applied under the mulch it provided much better weed control, and was only weak on lambsquarters. When on top of the mulch it was weak on galinsoga and lambsquarter. Treflan did not reduce the quality of any of the plants.

# THE EFFECT OF HERBICIDE AND MULCH PLACEMENT ON BEDDING PLANT TOLERANCE

Andrew Senesac[1]

## ABSTRACT

In many landscaped areas where annual bedding plants are used, organic mulches are usually only partially successful in suppressing weeds. There is interest in combining preemergence herbicides with mulches to improve weed control. Previous research by other workers has indicated that the mulch may act as a herbicide safener for the more sensitive bedding plant species.

The objective of this research was to determine whether bedding plant tolerance is affected by the formulation or placement, relative to mulch, of two preemergence herbicides, napropamide(4.45 kg/ha) and oxadiazon(3.3 kg/ha). In 1992, a field study was conducted at the Long Island Horticultural Research Laboratory. Marigold (Tagetes patula L. 'Janie'), petunia (Petunia x hybrida Hort. 'Primetime Red') , fibrous-rooted begonia (Begonia x semperflorens-cultorum Hort. 'Vodka') and impatiens (Impatiens wallerana Hook. 'Accent Lilac') were transplanted into Riverhead sandy loam on May 28. Herbicide treatments were applied either before or after application of a 5 cm mulch of composted mixed hardwoods. The plots were irrigated immediately post-treatment and as needed during the season. Visual evaluations of plant vigor and weed control were recorded and the bedding plants were harvested 47 days after treatment.

Although weed pressure was not heavy, the results indicate that broadleaf weed control was improved somewhat by the mulch alone. The mulch improved the weed control of oxadiazon 50 wp and napropamide 5G, irrespective of placement.

Both formulations of napropamide caused injury to all four bedding plant species. Napropamide activity was not greatly affected by mulch.

Oxadiazon 2G caused severe injury when no mulch was present. The injury was more severe on begonia and impatiens than marigold and petunia. When oxadiazon 2G was applied either under or over mulch, the injury was less severe in all cases. Interestingly, the opposite was the result when oxadiazon 50 wp was applied. Although some injury occurred with no mulch, it was much worse in the presence of mulch, particularly on begonia and impatiens. Mulch placement was not a significant factor with this formulation.

The results of this study indicate that, although mulch can have a safening effect on some herbicide formulations, it is not a universal effect. In one case it appeared to increase injury to the more sensitive species. The placement of the herbicides appeared to have more of an effect on weed control than bedding plant safety.

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# POSTEMERGENCE YELLOW NUTSEDGE CONTROL USING MON 12037

W. D. Ward and J. F. Derr[1]

## ABSTRACT

Experiments were conducted for 1992 to determine the effectiveness of MON 12037 for postemergence control of yellow nutsedge in ornamental crops. MON 12037, in a 75DF formulation, was applied at 0.031, 0.063, 0.125, and 0.25 lb a.i./acre in combination with a nonionic surfactant to yellow nutsedge 4 to 6 inches tall. For comparison, chlorimuron at 0.008 lb/A, imazaquin at 0.125 lb/A, and bentazon at 1.0 lb/A, also in combination with a nonionic surfactant, were included in the evaluation. In addition, a weedy check and a cultivated check were included; growth rates of ornamentals in these plots were compared with those of ornamentals in treated plots. Plots were 6 feet wide by 25 feet long. Included in the plots were newly transplanted 'Hershey's Red' azaleas (Rhododendron obtusum 'Hershey's Red') and roundleaf Japanese holly (Ilex crenata 'Rotundifolia'); five plants of each species were planted in two rows in each plot, with 2 feet between each plant and 2 feet between species. Azaleas were 4.5-to-7-inch-tall liners, and hollies were 6-to-7-inch-tall liners. MON 12037 at 0.031 lb/A controlled yellow nutsedge 69% 3 weeks after treatment (WAT) and 38% 7 WAT. At 0.063 lb/A, yellow nutsedge was controlled 70% 3 WAT and 45% 7 WAT. Increasing the rate of MON 12037 to 0.125 lb/A increased control to 78% 3 WAT and 80% 7 WAT, while an additional increase to 0.25 lb/A increased control to 85% 3 WAT and 94% 7 WAT. In comparison, chlorimuron, imazaquin, and bentazon controlled yellow nutsedge 3 WAT 66%, 38%, and 19%, respectively, with control decreasing 7 WAT to 40%, 1%, and 0%, respectively. Only slight damage was observed on ornamentals, perhaps due to yellow nutsedge, whose foliage may shaded the nursery crops from the spray to some extent. Nursery crop shoot fresh weights were recorded 12 WAT; compared to plants in the cultivated check, azalea shoot fresh weight was reduced by 49% and holly shoot fresh weight was reduced by 41% in the weedy check. MON 12037 at 0.031 lb/A reduced azalea and holly shoot fresh weights by 35% and 32% respectively, while MON 12037 at 0.25 lb/A reduced azalea and holly shoot fresh weights by 13% and 5%, respectively. Imazaquin was the only treatment to show extreme slowing of growth in azalea, with a 73% reduction in shoot fresh weight in comparison to the plants in the cultivated check; holly shoot fresh weight in imazaquin-treated plots was reduced by 37%.

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# YELLOW NUTSEDGE CONTROL USING P. CANALICULATA, BENTAZON, AND CHLORIMURON IN AZALEAS AND PIERIS

J. Ray Frank[1], C. Edward Beste[2], William L. Bruckart[1], and Dennis R. Johnson[1]

## ABSTRACT

Yellow nutsedge rust (*Puccinia canaliculata*) was applied alone or in combination with bentazon at 0.4 kg ai ha or chlorimuron at 0.009 kg ai ha to determine their potential to control yellow nutsedge (*Cyperus esculentus* L.) in newly planted 'Tradition' azaleas (Rhododendron x 'Tradition') growing in raised field beds. Bentazon at 0.8 kg ai ha and chlorimuron at 0.018 kg ai ha were also evaluated. Evaluations were made at 30 and 75 days (season's end) to determine the treatment effects on percent nutsedge cover, stand count, phytotoxicity (necrosis), nutsedge tuber count, and tuber weight.

Bentazon alone at 0.4 and 0.8 kg/ha reduced nutsedge cover 53 and 50% respectively, after 30 days. The addition of the nutsedge rust to bentazon at 0.4 kg/ha did not further reduce nutsedge cover (45%). The rust alone reduced the nutsedge cover 42%. No bentazon treatment alone or in combination with the rust significantly reduced nutsedge cover after 75 days, however.

At 30 days chlorimuron at 0.018 or 0.009 kg/ha reduced nutsedge cover 78 and 82% respectively. When chlorimuron was applied at 0.009 kg/ha in combination with the rust, nutsedge cover was reduced 85%. This combination also continued to reduce nutsedge cover significantly (45%) at the end of the growing season.

No herbicide treatment or combination with the rust significantly reduced yellow nutsedge total tuber count, total tuber weight, or average tuber weight. No phytotoxicity or growth reduction was observed on 'Tradition' azaleas with either herbicide alone or in combination with the yellow nutsedge rust.

Yellow nutsedge rust was also evaluated in a separate study in established Pieris (*Pieris japonica* (Thunb.) D. Don ex G. Don) at 7, 70, and 700 gm/ha of rust spores for control of yellow nutsedge. Phytotoxicity to the total leaf area of the nutsedge was 17.5% at 10 days following an application of 700 gm/ha of rust spores. Thirty days after this treatment, the number of rust pustules per nutsedge plant was 63% higher than those on the untreated control plants. No rust treatment alone in this experiment led to a reduced nutsedge stand count, or tuber number. A significant reduction in tuber weight (53%) was observed at harvest following the 700 gm/ha application.

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# PREEMERGENT TANK MIXES WITH MON 13200 FOR CONTROL OF SUMMER ANNUALS, WINTER ANNUALS, AND YELLOW NUTSEDGE

**Joseph C. Neal and Andrew F. Senesac[1]**

## ABSTRACT

Three experiments, were conducted to evaluate MON 13200 (proposed name - thiazopyr) applied alone and in combinations for weed control in nursery crops. In first test at Riverhead, NY, conducted on a Riverhead sandy loam soil, thiazopyr 2EC (MON 13211) was applied at 0.5 lb ai/A alone and in combination with 0.25 lb/A isoxaben, 3 lb/A metolachlor, 2.4 lb/A norflurazon, 2 lb/A oryzalin, or 1 lb/A oxyfluorfen. Treatments were applied to clean cultivated soil on 7 May 1992. Weeds present included yellow nutsedge (*Cyperus esculentus* L.), lambsquarters (*Chenopodium album* L.), Pennsylvania smartweed (*Polygonum pennsylvanicum* L.), and yellow goat's beard (*Tragopogon dubius* Scop.). In Ithaca, NY, thiazopyr was applied at 0.25, 0.38, and 0.5 lb/A alone and in combination with metolachlor at 3 lb/A. The soil, a silty clay loam, was clean cultivated before treatment on 13 May 1992. Weeds present at that site included lambsquarters, Powell amaranth (*Amaranthus powellii* S.Wats.), hairy galinsoga (*Galinsoga ciliata* (Raf.) Blake), velvetleaf (*Abutilon theophasti* Medicus), smooth crabgrass (*Digitaria ischaemum* (Schreb. ex Schweig.) Schreb. ex Muhl.), witchgrass (*Panicum capillare* L.), and yellow foxtail (*Setaria glauca* (L.) Beauv.). In the container test, weeds were seeded in a peat-based medium. Herbicides were applied on 19 August 1992. MON 13212 (a 0.5% granular formulation of thiazopyr) was applied at 0.25, 0.38, and 0.5 lb/A alone or in combination with dithiopyr at 0.5, 0.75 and 1.0 lb/A. Weeds included common chickweed (*Stelaria media* L.), mouseear chickweed (*Cerastium vulgatum* L.), galinsoga, yellow woodsorrel (*Oxalis stricta* L.), hairy bittercress (*Cardamine hirsuta* L.), dandelion (*Taraxacum officinale* Weber in Wiggers), horseweed (*Conyza canadensis* (L.) Cronq.), common groundsel (*Senecio vulgaris* L.), and annual bluegrass (*Poa annua* L.). All tests were conducted in randomized complete block designs with four replicates.

In the first field test, both lambsquarters and smartweed were controlled 100% by thiazopyr at 0.5 lb/A. Total weed cover was 14% with this treatment. When combined with other herbicides total weed cover was reduced to 8% with metolachlor and $\leq$3% with isoxaben, norflurazon, oryzalin, or oxyflurofen. However, yellow nutsedge was only controlled with metolachlor. Thiazopyr did not control yellow goat's beard. In the second field test, summer annual grasses were controlled 100% with 0.25 lb/A thiazopyr. Of the annual dicots present only lambsquarters was controlled by thiazopyr alone, 100% at 0.5 lb/A. Galinsoga, Powell amaranth, and velvetleaf control was between 65% & 70% at 0.5 lb/A. Tank mixing 0.5 lb/A thiazopyr and 3 lb/A metolachlor improved control of each of these dicot weeds to $\geq$88%. In the container test, 0.5 lb/A thiazopyr provided good to excellent control of annual bluegrass and yellow woodsorrel, fair control of galinsoga and mouseear chickweed, and poor to no control of dandelion, horseweed, groundsel, common chickweed and bittercress. At 1 lb/A, dithiopyr 1G provided good to excellent control of annual bluegrass, galinsoga, common chickweed, dandelion, groundsel, horseweed, and yellow woodsorrel, fair control of mouseear chickweed, and poor control of bittercress. Tank mixing 0.5 lb thiazopyr with 1 lb/A dithiopyr provided $\geq$85% control of all species.

In these tests thiazopyr controlled several important weeds of nursery crops but combinations with other herbicides were required to expand the spectrum of weeds controlled. Further research is needed to define optimum rates and combinations for the broadest spectrum of control without crop injury.

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# CONTROLLING YELLOW FOXTAIL AND COMMON RAGWEED IN NURSERY STOCK WITH PREEMERGENCE HERBICIDES

Scott Guiser and Larry Kuhns [1]

## ABSTRACT

The purpose of this study was to evaluate the preemergence weed control provided by several recently developed herbicides alone and in combination with herbicides commonly used in nurseries. The commercially formulated combination of isoxaben and oryzalin was compared to a combination containing less isoxaben. The nine herbicide treatments listed in Table 1 were applied on May 5, 1992 over the top of river birch (Betula nigra L.), inkberry holly [Ilex glabra (L.) Gray] and sourwood [Oxydendrum arboreum (L.) DC.] that had been planted in April 1992. A randomized complete block design was used with three replications per species. Plot size was three by ten feet; the soil was a Bedington silt loam. Just prior to application the plots were hoed to remove small weed seedlings. Herbicides were applied with a $CO_2$ pressurized test plot sprayer through 8006E nozzles at 30 psi in the equivalent of 31 gallons of water per acre. Soil and air temperature were both 50 degrees F. The plants were observed for signs of injury one, two and three months after treatment. The predominant weed species in the plots were yellow foxtail [Setaria lutescens (Weigel) Hubb.] and common ragweed (Ambrosia artemisiifolia L.). Data for birch and inkberry plots were combined (Table 1).

Isoxaben plus oryzalin provided very good control of ragweed and yellow foxtail regardless of the isoxaben rate. Norflurazon alone provided very good control of both weeds; combining simazine with it slightly increased the level of control. Dithiopyr provided good control of ragweed and excellent control of yellow foxtail. Prodiamine alone provided excellent control of yellow foxtail but poor control of common ragweed. Combined with simazine, it provided excellent control of both weed species. MON 12051 provided total control of common ragweed but no control of yellow foxtail.

Only norflurazon caused any injury symptoms to nursery stock. One and two months after treatment birch and sourwood leaves exhibited veinal chlorosis and were slightly stunted. Three months after treatment no symptoms were evident.

All of the herbicides tested are potentially of use in nurseries. Those that do not control a broad spectrum of weeds simply need to be combined with other herbicides that will control the weeds missed. Except for norflurazon, none of the herbicides injured plants in the test, which were at their most sensitive stage of growth at the time of application. The injury caused by norflurazon could possibly be avoided by applying it as a directed spray, rather than over-the-top as was done in this study.

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Table 1. Percent control of yellow foxtail and common ragweed with preemergence herbicides. Treatments were applied May 5 and rated August 25.

| Treatment | Rate lbs ai/A | Percent Control yellow foxtail | common ragweed |
|---|---|---|---|
| control | - | 0c[z] | 0c |
| prodiamine | 1.5 | 100a | 54b |
| norflurazon | 3.0 | 88b | 92a |
| isoxaben + oryzalin | 0.75 + 2.25 | 75b | 95a |
| isoxaben + oryzalin | 0.25 + 2.25 | 90ab | 88ab |
| prodiamine + simazine | 1.5 + 2.0 | 95ab | 97a |
| norflurazon + simazine | 2.4 + 2.0 | 93ab | 100a |
| dithiopyr | 2.0 | 100a | 68ab |
| MON 12051 | 0.062 | 0c | 100a |
| MON 12051 | 0.125 | 0c | 100a |

[z] Means of six replications. Means within columns followed by the same letter are not significantly different as calculated by the Waller-Duncan K-ratio t test. K ratio = 100.

V GOOD NOT 100%

RIV BIRCH + INJURED BY NORFLURAZON

# IDENTIFICATION, BIOLOGY, AND CONTROL OF YELLOW GOAT'S BEARD, AN INCREASING PROBLEM IN NURSERY CROPS.

R.H. Uva[1], A.F. Senesac[2], and J.C. Neal[3]

## ABSTRACT

Western salsify (Tragopogon dubius Scop.), a member of the Asteraceae, also known as yellow goat's beard, is a biennial native to Europe which now is distributed throughout North America, and throughout the Northeast. Western salsify has recently increased in numbers in nursery crops on Long Island, NY. Forming a grass-like rosette, young seedling leaves may superficially resemble some grass. At maturity western salsify produces an erect grass-like rosette which can grow to 25 cm in height with a peduncle to 80 cm in height. The flowers of the composite head are all ligulate, yellow, and produce achenes tufted with pappus. Western salsify has a taproot and does not reproduce vegetatively. Meadow salsify (Tragopogon pratensis L.), although a distinct species, is similar to western salsify morphologically and biologically.

Seeds of western salsify do not persist in the soil. In one study it was found that the seeds did not survive in the soil for greater than 2 years. A new appearance in a location is most likely due to long distance wind dispersal or introduction in plant materials or on farm equipment. The seeds are topped with a whitish pappus, which consists of a series of feathery bristles with interwoven branches, allowing the seed to travel > 250 m.

Although classified as a biennial, western salsify may persist in rosette form as long as 8-10 years before flowering depending on the individuals growth rate. One study found that rosette root crown diameter in the fall determines if an individual will die, flower, or remain vegetative during the next growing season. Another study found that seedlings had a high mortality rate (50%) prior to winter.

As cropping practices change, the competitive ability of certain weeds change. A current trend in nursery production is the move towards increased use of cover crops. The reduction in herbicide use associated with this practice may have resulted in this recent increase in numbers of western salsify. Germination before cover crop establishment could explain the increased numbers, also, the grass-like morphology of both seedlings and mature western salsify could give it an increased competitive ability in cover crops over the prostrate basal rosettes of other weeds.

Preemergence herbicide trials were conducted on western salsify at the Long Island Horticultural Research Laboratory in 1992. Norflurazon gave excellent control at 2.4 lb ai/A. Oxyfluorfen (1.0 lb ai/A), oryzalin (2.0 lb ai/A), and isoxaben (0.25 lb ai/A) all gave good control. The few weeds which survived these treatments were stunted by oxyfluorfen and oryzalin but those in the isoxaben plots were as large as those in the untreated area. Metolachlor (3 lb ai/A) and thiazapyr (0.5 lb ai/A) gave poor to no control. Tank mixed combinations did not enhance control over products applied individually.

Taking into consideration the control recommendations given above and the short period of time seeds remain viable in the soil, and barring wind borne reintroductions, with an intensive control program western salsify could be eradicated from a field in two years.

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# MON 12000: A NEW HERBICIDE FOR POSTEMERGENCE BROADLEAF WEED CONTROL IN CORN.

J.A. Ricotta and L.D. Bradshaw[1]

MON 12000 is a new dry flowable herbicide being developed by Monsanto Company for postemergence broadleaf weed control in corn. The herbicide is used without a safener at 0.018 to 0.036 kg ai $ha^{-1}$. Field trials were conducted nationwide from 1987 to 1992 to determine the crop safety and weed control efficacy. MON 12000 at 0.036 kg $ha^{-1}$ applied to 2 to 8 leaf corn caused negligible injury, offering a wide window of application. Weed control efficacy was equal to or greater than the competitive standards. MON 12000 provided 82% and 90% control of 8 to 30 cm common cocklebur (Xanthium strumarium) and velvetleaf (Abutilon theophrasti), respectively. Control of common ragweed (Ambrosia artemisiifolia), pennsylvania smartweed (Polygonum pennsylvanicum) and redroot pigweed (Amaranthus retroflexus) was greater than 90%. MON 12000 at 0.018 kg $ha^{-1}$ combined with dicamba or 2,4-D at 0.28 kg $ha^{-1}$ controlled 85% of both ivyleaf morningglory (Ipomoea hederacea) and common lambsquarters (Chenopodium album) that were as tall as 30 cm. Tank mixes of MON 12000 and postemergence grass herbicides provided broadspectrum control of many narrow and broadleaf weed species. Corn injury was minimal with all combinations tested.

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SUMMER-FALL USE

EQUISETUM ?
OUST CONTROLLES
HORSEWEED
& @
DANDELION

ATHRENS
OUST - SUC FOMETURON
- INJURED CONIFERS EARLY ON
- APPLIED AT:
FRAZIER FIR
CONTROLLED ERICA WEED
AMARE
TATROF @ 1/2-1 oz/A

HEMLOCKS - SUMMER APPL.
INJURED BEDS

APPLY AFTER NEW GROWTH IS COMPLETED

YEAR ESTABLISHED
F. FIR
F. FIR.

# ANNUAL WEED CONTROL IN CORN WITH SAN 582H

**P. C. Bhowmik and B. M. O'Toole[1]**

## ABSTRACT

Field experiments were conducted in 1992 to evaluate the effectiveness of SAN 582H in controlling annual grass and broadleaf weeds in field corn. Four rates of SAN 582H (0.56, 0.84, 1.12, and 1.40 kg $ha^{-1}$) were compared to four rates of alachlor-MT and metolachlor (each at 1.12, 1.68, 2.24, and 2.80 kg $ha^{-1}$). Treatments were applied preemergence on May 13, 1992. The effects of timing of application of SAN 582H on weed control and plant injury was investigated in another experiment. SAN 582H at 1.26 kg $ha^{-1}$ was applied with a pre-mix combination of atrazine and dicamba (1.57 kg $ha^{-1}$) at three growth stages of corn. Treatments were applied preemergence on May 7, on May 19 for the spike stage, and on May 26 for the two- to three-leaf stage.

Each plot was 2.3 by 6.1 m and treatments were replicated three times in a randomized complete block design. Corn 'Agway Expt. 511' was planted May 5 and 12, 1992. Treatments were applied with a $CO_2$-backpack sprayer at a pressure of 152 kPa in 187 L/ha. Major weed species were large crabgrass [Digitaria sanguinalis (L.) Scop.], common lambsquarters (Chenopodium album L.), fall panicum [Panicum dichotomiflorum (L.) Michx.] and velvetleaf (Abutilon theophrasti Medik.). Corn height was determined 8 weeks after treatment (WAT). Corn injury was visually rated 4 and 9 WAT. Weed control was rated (0 to 100 scale) 4, 9 and 14 WAT.

In the rate study, SAN 582H, alachlor-MT and metolachlor at all rates resulted in 97 to 99% control of large crabgrass and fall panicum 4 WAT. The four rates of SAN 582H gave 95 to 99% control of large crabgrass and 96 to 98% control of fall panicum 9 WAT. The 0.56 and 0.84 kg $ha^{-1}$ rates of SAN 582H gave 91 and 93% control of large crabgrass, respectively, 15 WAT. Neither corn height nor silage or grain yields were reduced by any of the treatments.

In the second experiment, the combination of SAN 582H and the pre-mix of atrazine + dicamba (1.26 + 1.57 kg $ha^{-1}$, respectively) applied preemergence gave good to excellent control of large crabgrass, common lambsquarters, and velvetleaf 4 WAT. The same treatment applied at the spike stage of corn gave reduced control of large crabgrass and velvetleaf at 9 WAT (88%, 85%) and 14 WAT (83%, 82%). The treatment of alachlor-MT plus the pre-mix of atrazine + dicamba (2.8 + 1.57 kg $ha^{-1}$) applied at the spike stage gave only 72% control of large crabgrass 14 WAT.

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# WEED CONTROL AND FIELD CORN TOLERANCE TO SAN 582H.

D. G. Eastman[1]

## ABSTRACT

SAN 582H is a unique thiophene-based chloroacetamide discovered by Sandoz Agro Ltd.in Basel, Switzerland. Mode of action studies show that the entry of SAN 582H is primarily through the coleoptiles of germinating grasses killing weeds by reducing plant cell division and growth. Field tests have demonstrated that SAN 582H is a herbicide which provides consistent high performance weed control across a wide range of environmental conditions in the Northeastern U.S.

It has a flexible application timing and soil applied use rates lower than most competitive standards in field corn (Zea mays L.). Applications in field corn may be made prior to weed emergence from early preplant to early postemergence. Active ingredient use rates are 0.70 to 1.50 lb ai per acre (0.80 to 1.70 kg $ha^{-1}$ ) dependent on soil texture and organic matter. SAN 582H controls annual grasses (Digitaria spp., Setaria spp., Panicum spp., and Echinochloa crus-galli and others) and controls or suppresses many broadleaf weeds and yellow nutsedge (Cyperus esculentus L.). Tank mixtures or sequential applications of broadleaf herbicides with SAN 582H have provided a complete weed control program and excellent crop safety.

SAN 582H 7.5 EC is the primary formulation used in field performance evaluations. In 1992, a large scale experimental use program was initiated to test SAN 582H with growers. A total of 164 trials in 21 states were conducted in corn. Growers used SAN 582H at projected use rates as a replacement for their grass herbicide component. They evaluated crop safety, weed control and product performance favorably in direct comparisons with their standard programs.

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# BROADLEAF WEED CONTROL WITH CGA-152005, A NEW HERBICIDE FOR CORN

C. C. Kupatt[1], G. R. Gillespie[1], J. W. Peek[1], and H. R. Gerber[2], W. Meyer[2], K. Oertle[2], M. Schulte[2]

CGA-152005 is a new herbicide under development by CIBA-GEIGY for broadleaf weed control in corn. When applied at rates of 20 to 40 g ai/ha postemergence, CGA-152005 provides excellent control of most major broadleaf weed species in corn, including velvetleaf (Abutilon theophrasti Medicus), lambsquarters (Chenopodium spp.), pigweeds (Amaranthus spp.), cockleburs (Xanthium spp.), ragweeds (Ambrosia spp.), morningglories (Ipomoea spp.), as well as other important annual and perennial dicots. Control of grasses and nightshades (Solanum spp.) is generally poor. Crop tolerance to postemergence applications of 80 g ai/ha and higher is excellent. CGA-152005 also has soil activity against many important broadleaf weeds, particularly small-seeded dicots, at rates between 10 and 40 g ai/ha, as well as residual activity from postemergence applications. Preemergence use may be limited by marginal crop tolerance at rates above 15 g ai/ha. Under normal corn-growing conditions, soybeans, cereal grains, sorghum, and many other rotational crops have not shown injury when grown in the year following an application of CGA-152005 at 40 g ai/ha. The oral $LD_{50}$ (rat) for CGA-152005 is 986 mg/kg; it is not a skin sensitizer, was negative in the Ames test, is not an eye irritant, and shows low toxicity to wildlife. Chronic toxicology studies are in progress. CGA-152005 has shown no dependence on corn hybrids for tolerance. CGA-152005 will provide new opportunities for the selective control of broadleaf weeds in corn.

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# The Influence of a Hairy Vetch (Vicia villosa) Cover Crop on Weed Control in Corn

W. S. Curran and L. D. Hoffman[1]

## ABSTRACT

Cover crops are promoted for reducing soil erosion, providing or scavenging nitrogen, and possibly suppressing weed growth and competition. Hairy vetch is a cover crop that appears to do well in Pennsylvania conditions. However, methods for killing or suppressing hairy vetch and the residual weed control requirement for the cover crop-grain crop system have not been well defined. The objectives of the following study were to determine the best method of killing hairy vetch prior to corn establishment and to identify the need for residual weed control.

The study was established in 1991 and 1992 in central Pennsylvania in a site that was previously in small grains. Hairy vetch was seeded in mid-August at 30 lb/A and killed the following May using either tillage, mowing, or a preplant application of the butoxyethyl ester of 2,4-D. Treatments containing no vetch were included for comparison. Residual herbicide treatments included 0.5, 0.75, or 1X the recommended rates of metolachlor plus atrazine, the recommended rate of a postemergence application of nicosulfuron plus thifensulfuron, or cultivation.

Vetch was adequately controlled with all preplant treatments in 1991, however mowing was less effective in 1992. The vetch recovered from the majority of the mowing treatments in 1992 probably due to the premature stage of development at the time of mowing. In 1991, the vetch was turning reproductive by mid-May, while in 1992, vetch development was delayed. Corn population was unaffected by cover crop method of kill or residual weed control treatment in 1991, but was significantly reduced in all vetch containing treatments in 1992, due to insect pests during corn emergence and inadequate vetch control in the mow treatments. Method of hairy vetch kill produced variable weed control results. In general, the treatments that left the greatest amount of vetch residue on the soil surface had fewer early season weeds compared to the tilled or no vetch plots. However, residual herbicide performance was better where less surface vetch residue remained. Annual weeds including smooth pigweed (Amaranthus hybridus L.) and giant and yellow foxtail (Setaria faberii Herrm. and Setaria lutescens (Weigel) Hubb.) were reduced in number with all three residual herbicide treatments as well as the postemergence application. Cultivation effectively reduced the weed population in 1991 preventing a reduction in grain yield, but did not sufficiently reduce the weed infestation in 1992. By late season, weed biomass was less in residual and postemergence herbicide treatments, but similar regardless of how the cover crop was killed.

In summary, mowing was not a dependable method for suppressing hairy vetch in corn. A preplant application of 2,4-D was effective at killing the hairy vetch and also providing a good surface mulch that sometimes inhibited early season weed emergence. Soil applied residual herbicide performance was reduced in the presence of hairy vetch residues, regardless of whether the cover was left on the surface or incorporated. Postemergence herbicide applications were equally effective in vetch and no-vetch containing plots and cultivation provided adequate weed suppression as long as the weed infestation was relatively light.

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# ESTABLISHMENT OF CROWNVETCH AND BIRDSFOOT TREFOIL COVER CROPS IN FIELD CORN

N. L. Hartwig[1]

## ABSTRACT

Cyanazine (Bladex), imazethapyr (Pursuit), imazapyr (Arsenal), pendimethalin (Prowl), metolachlor (Dual) and alachlor (Lasso) treatments were applied preemergence (pre) in various combinations to an imidazolinone (imazethapyr, Pursuit) resistant corn (Zea mays L) variety from Pioneer on the Penn State Agronomy Farm in 1991 (Table 1). Post emergence (post) treatments included nicosulfuron (Accent), primisulfuron (Beacon), imazethapyr (Pursuit) and bentazon (Basagran) in various combinations. On May 13, 1992, the whole trial area was treated with imazethapyr + pendimethalin at 0.0625 + 1.67 lb ai/A.

The soil was a Murrill Silt Loam (Typic Hapludult) with a pH of 6.1. All treatments were applied with a tractor mounted small plot sprayer with 80015 extended range flat fan nozzles at 187 kPa and 187 l/ha of water. A blanket treatment of glyphosate + 2,4-D LVE at 1.0 + 0.67 lb ai/A was applied preemergence on 4/24/91. 'Pioneer 3343' corn was planted in 4.57 by 6.1 m plots with a six row no-till planter in 76 cm rows on May 10, 1991 and May 22, 1992 with 110 kg/ha of 10-30-10 fertilizer in the row. Urea (150#/A of N) was broadcast over the whole trial area at corn planting time. Volunteer orchardgrass (Dactylis glomerata L.) was 20 to 25 cm tall and dandelion (Taraxacum officinale Weber in Wiggers) rosettes 5 to 10 cm when glyphosate and 2,4-D were applied in April. Control of these weeds, fall panicum (Panicum dichotomiflorum Michx.) and redroot pigweed (Amaranthus retroflexus L.) was virtually 100% for all treatments except those that didn't receive a preemergence treatment. Even the no herbicide check had >90% redroot pigweed control and >80% annual grass control so the trial area was relatively weed free.

Corn growth and yields were drastically reduced in 1991 due to the driest growing season since 1988. Corn stands were generally not significantly affected by any of the treatments. Corn height and yield were generally significantly greater where preemergence treatments were applied and weeds were effectively controlled early. Corn yields in excess of 100 bu/A would have to be considered excellent in 1991.

Birdsfoot trefoil (Lotus corniculatus L.) and crownvetch (Coronilla varia L.) were broadcast over the whole trial area at 11 + 11 kg/ha respectively on May 24, 1991. Birdsfoot trefoil was almost totally killed (<2% ground cover) by pre treatments containing cyanazine or post treatments of nicosulfuron + primisulfuron or imazethapyr + bentazon (Table 1). There was some establishment from all other pre treatments but the best pre treatments appeared to be imazethapyr + alachlor or metolachlor followed by nothing or imazethapyr post (>14% ground cover by 7/29/92). Imazapyr + alachlor pre with nothing post had 20% birdsfoot trefoil ground cover by 7/29/92. It has been noticed in other research that birdsfoot trefoil is very tolerant to imazapyr.

Although the trial was overseeded with crownvetch as well, there was not enough germination or establishment as a result of the extremely dry summer to be able to rate crownvetch cover in 1991. From past research, it is not uncommon to have such poor crownvetch establishment the first year so as to assume a total failure. However, by the middle of the summer of 1992, crownvetch cover was greater than 5% for almost all treatments except those that didn't receive a preemergence treatment. Crownvetch cover was 21% by 7/29/92 where imazethapyr + metolachlor was applied pre with nothing post. Other excellent treatments included cyanazine or imazapyr with alachlor or metolachlor pre with any treatment post (5 to 18% ground cover). With patience, good crownvetch stands can be obtained with any of these treatments.

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ble 1. Effects of 10 pre and 4 post treatment combinations on imidazolinone resistant corn and birdsfoot trefoil and crownvetch establishment when averaged over 4 reps.

| Treatment (see footnote a) | | | 7/2/91 | <-------7/22/91-------> | | <10/8/91> | <-7/9/91-> | <5/20/92> | <7/29/92> | <5/20/92> | <7/29/92> |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre | Post | Rate | Corn Injury | Corn Height | Corn Stand | Corn Yield | BFT Cover | BFT Cover | BFT Cover | CV Cover | CV Cover |
| | | lb ai/A or (x) oz product | % | cm | plants/A | bu/A | % | % | % | % | % |
| ıdex + Prowl | Nothing | 1.5 + 1.5 + 0 | 4 | 171 | 18,622 | 94 | 0 | 0 | 1 | 1 | 10 |
| ıdex + Prowl | Accent + Beacon | 1.5 + 1.5 + (0.6 + 0.1) oz | 5 | 174 | 19,602 | 115 | 0 | 0 | 0 | 1 | 8 |
| ıdex + Prowl | Pursuit | 1.5 + 1.5 + .0625 | 5 | 164 | 18,513 | 112 | 0 | 1 | 0 | 1 | 8 |
| ıdex + Prowl | Pursuit + Basagran | 1.5 + 1.5 + .0625 + .75 | 4 | 175 | 19,167 | 108 | 0 | 0 | 0 | 1 | 6 |
| ıdex + Dual | Nothing | 1.5 + 1.5 + 0 | 4 | 170 | 20,256 | 106 | 0 | 1 | 1 | 1 | 6 |
| ıdex + Dual | Accent + Beacon | 1.5 + 1.5 + (0.6 + 0.1) oz | 6 | 170 | 19,820 | 106 | 0 | 0 | 0 | 2 | 11 |
| ıdex + Dual | Pursuit | 1.5 + 1.5 + .0625 | 6 | 163 | 20,691 | 93 | 0 | 1 | 1 | 3 | 10 |
| ıdex + Dual | Pursuit + Basagran | 1.5 + 1.5 + .0625 + .75 | 5 | 168 | 20,255 | 113 | 0 | 0 | 0 | 1 | 5 |
| ıdex + Lasso | Nothing | 1.5 + 1.5 + 0 | 10 | 165 | 19,166 | 97 | 0 | 0 | 1 | 1 | 10 |
| ıdex + Lasso | Accent + Beacon | 1.5 + 1.5 + (0.6 + 0.1) oz | 3 | 170 | 20,691 | 108 | 0 | 0 | 0 | 2 | 13 |
| ıdex + Lasso | Pursuit | 1.5 + 1.5 + .0625 | 8 | 167 | 18,622 | 114 | 0 | 0 | 2 | 1 | 13 |
| ıdex + Lasso | Pursuit + Basagran | 1.5 + 1.5 + .0625 + .75 | 6 | 167 | 20,364 | 105 | 0 | 0 | 1 | 1 | 12 |
| 'suit + Prowl | Nothing | .0625 + 1.5 + 0 | 4 | 172 | 18,622 | 101 | 3 | 2 | 4 | 2 | 5 |
| 'suit + Prowl | Accent + Beacon | .0625 + 1.5 + (0.6 + 0.1) oz | 4 | 171 | 19,711 | 115 | 1 | 1 | 5 | 1 | 5 |
| 'suit + Prowl | Pursuit | .0625 + 1.5 + .0625 | 8 | 159 | 20,038 | 99 | 2 | 2 | 16 | 1 | 5 |
| 'suit + Prowl | Pursuit + Basagran | .0625 + 1.5 + .0625 + .75 | 5 | 168 | 19,275 | 111 | 1 | 0 | 1 | 1 | 3 |
| 'suit + Dual | Nothing | .0625 + 1.5 + 0 | 5 | 169 | 18,840 | 109 | 4 | 4 | 23 | 2 | 21 |
| 'suit + Dual | Accent + Beacon | .0625 + 1.5 + (0.6 + 0.1) oz | 10 | 171 | 20,522 | 113 | 1 | 2 | 2 | 2 | 9 |
| 'suit + Dual | Pursuit | .0625 + 1.5 + .0625 | 9 | 168 | 18,622 | 116 | 2 | 3 | 6 | 1 | 6 |
| 'suit + Dual | Pursuit + Basagran | .0625 + 1.5 + .0625 + .75 | 8 | 168 | 19,820 | 109 | 0 | 0 | 1 | 1 | 4 |
| 'suit + Lasso | Nothing | .0625 + 1.5 + 0 | 3 | 175 | 20,909 | 111 | 13 | 4 | 14 | 1 | 5 |
| 'suit + Lasso | Accent + Beacon | .0625 + 1.5 + (0.6 + 0.1) oz | 4 | 172 | 18,295 | 116 | 1 | 1 | 3 | 1 | 8 |
| 'suit + Lasso | Pursuit | .0625 + 1.5 + .0625 | 1 | 174 | 18,840 | 116 | 15 | 4 | 16 | 1 | 4 |
| 'suit + Lasso | Pursuit + Basagran | .0625 + 1.5 + .0625 + .75 | 0 | 172 | 20,473 | 112 | 1 | 0 | 1 | 1 | 7 |
| :enal + Prowl | Nothing | 0.03125 + 1.5 + 0 | 9 | 164 | 19,820 | 102 | 2 | 1 | 4 | 2 | 18 |
| :enal + Prowl | Accent + Beacon | .03125 + 1.5 + (0.6 + 0.1) oz | 9 | 165 | 17,751 | 106 | 0 | 1 | 1 | 2 | 10 |
| :enal + Prowl | Pursuit | 0.03125 + 1.5 + .0625 | 10 | 162 | 20,800 | 101 | 1 | 1 | 2 | 2 | 8 |
| enal + Prowl | Pursuit + Basagran | 0.03125 + .0625 + .75 | 9 | 161 | 19,820 | 114 | 0 | 0 | 0 | 2 | 5 |
| enal + Dual | Nothing | 0.03125 + 1.5 + 0 | 9 | 167 | 19,166 | 101 | 3 | 5 | 9 | 2 | 18 |
| enal + Dual | Accent + Beacon | .03125 + 1.5 + (0.6 + 0.1) oz | 11 | 151 | 20,038 | 100 | 0 | 1 | 7 | 3 | 18 |
| enal + Dual | Pursuit | 0.03125 + 1.5 + .0625 | 10 | 156 | 19,929 | 96 | 1 | 4 | 12 | 1 | 7 |
| enal + Dual | Pursuit + Basagran | 0.03125 + .0625 + .75 | 9 | 159 | 20,256 | 96 | 0 | 0 | 1 | 2 | 17 |
| enal + Lasso | Nothing | 0.03125 + 1.5 + 0 | 5 | 176 | 18,513 | 105 | 7 | 4 | 20 | 1 | 12 |
| enal + Lasso | Accent + Beacon | .03125 + 1.5 + (0.6 + 0.1) oz | 8 | 173 | 19,493 | 106 | 0 | 0 | 2 | 2 | 11 |
| enal + Lasso | Pursuit | 0.03125 + 1.5 + .0625 | 5 | 167 | 19,384 | 110 | 2 | 3 | 6 | 1 | 14 |
| enal + Lasso | Pursuit + Basagran | 0.03125 + .0625 + .75 | 5 | 171 | 18,404 | 114 | 0 | 0 | 0 | 1 | 5 |
| hing | Nothing | 0 + 0 | 15 | 144 | 18,186 | 55 | 2 | 3 | 12 | 1 | 1 |
| hing | Accent + Beacon | 0 + (0.6 + 0.1) oz | 14 | 160 | 18,186 | 90 | 1 | 4 | 29 | 1 | 2 |
| hing | Pursuit | 0 + .0625 | 13 | 157 | 19,058 | 82 | 9 | 8 | 16 | 0 | 1 |
| hing | Pursuit + Basagran | 0 + .0625 + .75 | 10 | 160 | 19,711 | 85 | 0 | 0 | 1 | 1 | 4 |
| | Signif. Level (P) | | 0.9747 | 0.7657 | 0.5247 | 0.9158 | | | | | |
| | LSD (P=0.05) | | 8 | 12 | 2,126 | 18 | | | | | |

**Note:** Post treatments included X-77 + 32% N Soln. @ 0.25% +1.25%

a Apr. 24, 1991 - Whole trial area treated with Ranger + 2,4-D LVE @ 1.0 + 0.67 lb ai/A

# DEVELOPMENT OF PIONEER HERBICIDE RESISTANT CORN

B. D. McBratney[1]

## ABSTRACT

American Cyanamid gave Pioneer Hi-Bred International, Inc. exclusive rights in 1985 to use the gene giving imidazolinone resistance in corn. This source of resistance was developed by Molecular Genetics, Incorporated who used in vitro selection with corn callus to develop a strain of corn resistant to imidazolinones. MGI did this by growing corn cells on a nutrient medium which contained the herbicide. Most of the cells were killed, but a few continued to grow because they had a mutation in the enzyme which is a target for the herbicide. The slight change in the single gene resulted in corn cells resistant to the herbicide. The resistant plants have an altered form of the gene coding for AHAS (acetohydroxyacid synthase, an enzyme necessary for synthesis of the amino acids valine, leucine, and isoleucine) such that AHAS resists inhibition by imidazolinones. Pioneer initiated a backcrossing program to transfer the herbicide resistant gene into Pioneer elite inbreds (parents of hybrids). The goal was to develop inbreds which differed from the original inbreds only in resistance to Pursuit (imazethapyr). Backcrossing is initiated by making a hybrid between an inbred carrying the resistance gene and a susceptible elite inbred. A number of plants are produced from this cross, sprayed with imazethapyr, and only surviving plants kept. These surviving plants are again crossed to the elite inbred and plants from this cross (designated BC1 plants) are sprayed with imazethapyr and again only surviving plants kept (Figure 1). This procedure is done four to six times until the elite inbred with resistance is found. The new inbred containing resistance will be 97 to 99 percent similar to the original elite inbred. Converted hybrids perform similar to the non-converted hybrids. To assure converted perform as well as non-converted hybrids, inbred and hybrid yield tests are conducted to test performance. These tests help to describe similarities as well as differences.

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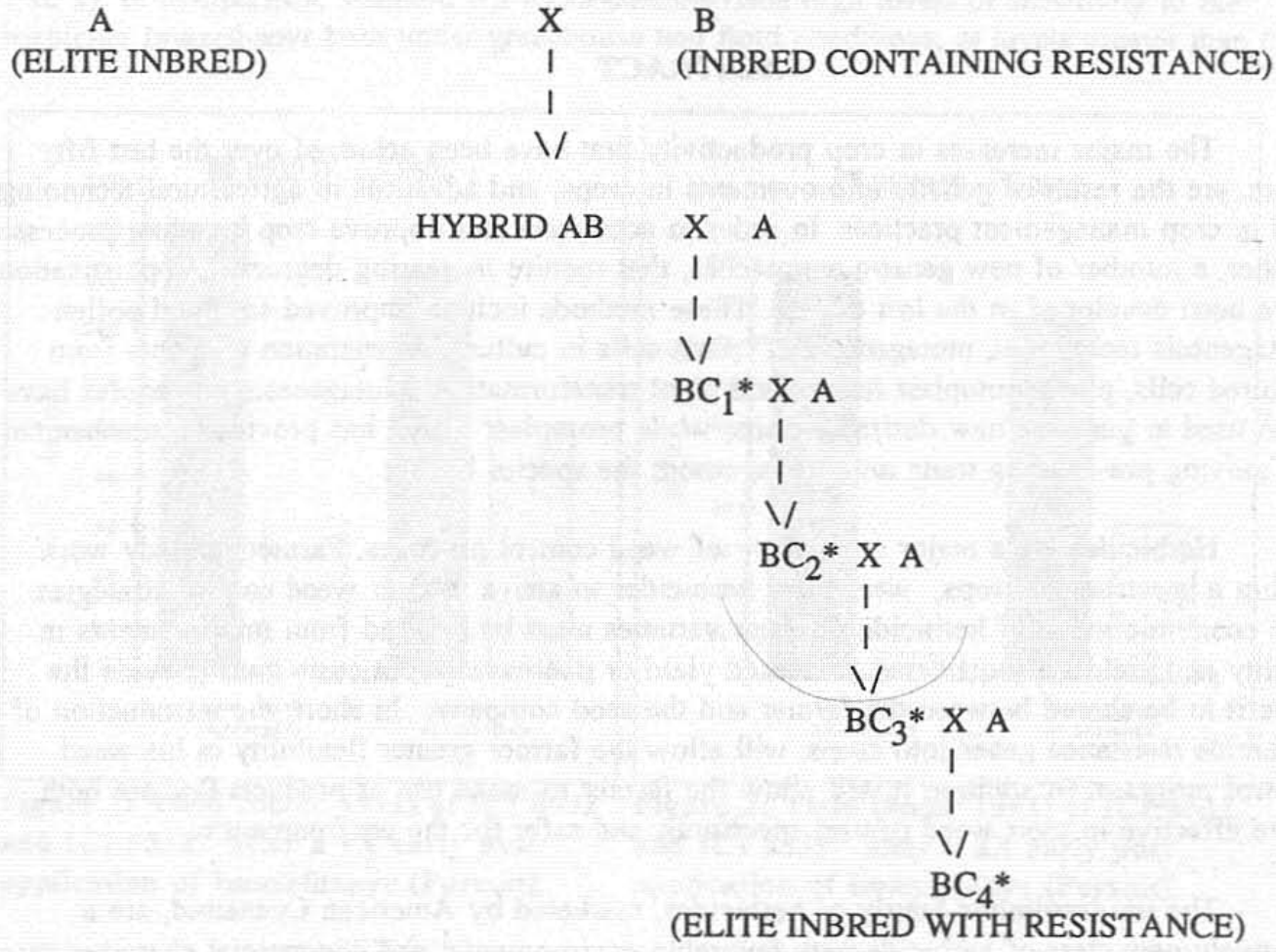
FIGURE 1. Development of a herbicide resistant inbred through backcrossing.




* Only plants which survived after spraying with imazethapyr are used to cross with elite inbred.

# DEVELOPMENT OF RESISTANCE TO THE ALS INHIBITOR IMAZETHAPYR (PURSUIT) IN COMMERCIAL CORN HYBRIDS

John A.Greaves[1]

## ABSTRACT

The major increases in crop productivity that have been achieved over the last fifty years, are the result of genetic improvements in crops, and advances in agricultural technology and in crop management practices. In order to accelerate and improve crop breeding processes further, a number of new genetic approaches, that require increasing degrees of sophistication, have been developed in the last decade. These methods include improved seed and pollen mutagenesis techniques, mutagenesis of plant cells in culture, regeneration of plants from cultured cells, plant protoplast fusion, and plant transformation. Mutagenesis procedures have been used to generate new desirable traits, while protoplast fusion has provided a mechanism for moving pre-existing traits into crops, across the species barrier.

Herbicides are a major component of weed control practices. Farmers already work within a spectrum of crops, weeds and herbicides to arrive at their weed control strategies. The economic value of herbicide resistant varieties must be realised from improvements in quality and yield. In most cases, increased yield or decreased input costs must provide the benefit to be shared between the farmer and the seed company. In short, the introduction of herbicide resistance genes into crops, will allow the farmer greater flexibility in his weed control program. In addition it will allow the farmer to make use of products that are both more effective in their weed control spectrums, and safer for the environment.

The imidazolinone family of herbicides, marketed by American Cyanamid, are a relatively new class of herbicide with favorable environmental and commercial characteristics. They possess a high degree of biological potency, which makes them effective at low application rates. Sensitive plants are killed by the inhibition of acetolactate synthase which catalyses the first step in the biosynthesis of the branched amino acids valine, leucine and isoleucine (1). Although this family of herbicides are targetted for soybean weed control, such characteristics have made the imidazolinones (eg. Imazethapyr (Pursuit)), useful for weed control in corn. However, corn is inherently sensitive to currently used imidazolinone herbicides such as Imazethapyr (Pursuit) and Imazaquin (Scepter).

In 1988, ICI Seeds began the development of Imazethapyr Tolerant (IT) corn, and in 1991, launched the world's first commercially available Imazethapyr Tolerant corn hybrid 8532$^{IT}$. The technique of pollen mutagenesis was used to induce a dominant mutation in the ALS2 gene, located on the long arm of chromosome 5. The single point mutation resulted in a high degree of resistance to the ALS-inhibiting herbicide Imazethapyr (Pursuit). From the large number of plants originally screened, one resistant individual was selected and progressed to inbred status. Plants carrying only one copy of the resistance gene (being heterozygous at the ALS2 locus), demonstrated levels of resistance, under greenhouse conditions, to well above five times the recommended application rate of Imazethapyr in soybeans. In subsequent field trials, both in house and at universities in the

Mid-West, the resistant hybrid (ICI 8532[IT]), demonstrated high levels of resistance, with no significant reduction in grain yield when Imazethapyr was applied at pre-plant incorporated rates of 0.25X, 0.5X, 1.0X, 2.0X and 5.0X; and post-emergence rates of 1.0X, 2.0X (Figures 1 & 2). In comparison, standard ICI 8532 demonstrated high levels of sensitivity to the herbicide Imazethapyr both under greenhouse and field conditions, at levels greater than 0.5X.

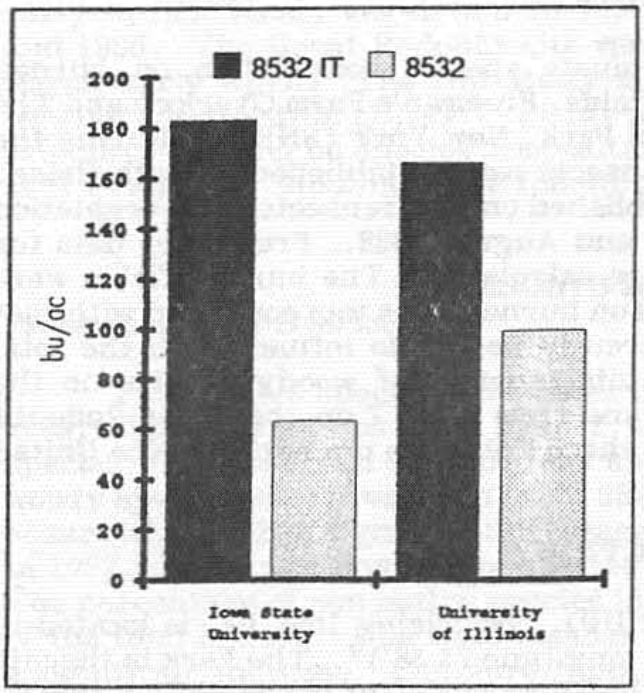



**Figure 1: Yield (bu/ac 1991) of ICI 8532 and ICI 8532[IT] after a 1X early post application of Imazethapyr (Pursuit).**

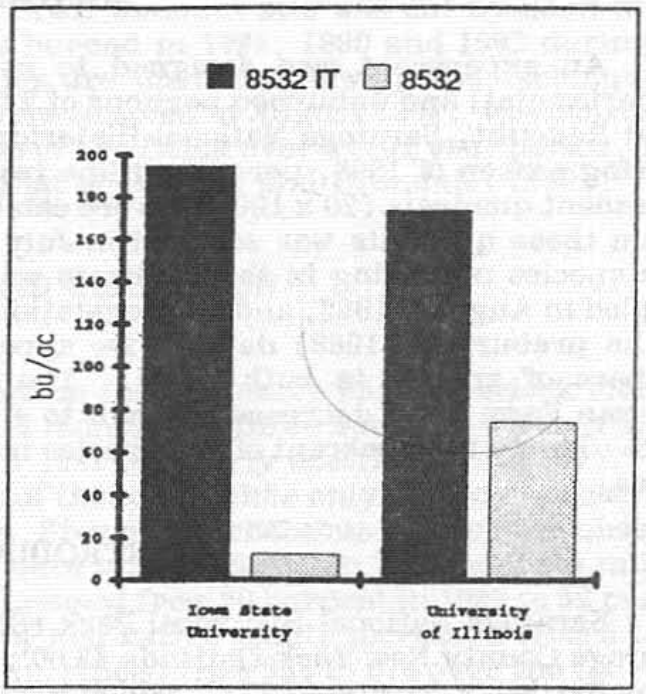



**Figure 2: Yield (bu/ac 1991) of ICI 8532 and ICI 8532[IT] after a 2X early post application of Imazethapyr (Pursuit).**

## Literature Cited

(1) Shaner, D.L., Anderson, P.C., & M.A. Stidham, 1984. Imidazolinones: potent inhibitors of acetohydroxyacid synthase. Plant Physiology 76: 545-546.

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[1] Plant Physiologist, ICI Seeds, Research Department, P.O.Box 500, Slater, IA50244.

# A FOUR YEAR STUDY OF THE EFFECT OF FIRE ON THE VEGETATION IN TWO FIELDS, SARATOGA NATIONAL HISTORICAL PARK (SNHP), NEW YORK

R. Stalter[1] and J. Schaberl[2]

## ABSTRACT

An experiment was designed to evaluate species composition on burned (experimental) and unburned portions of 2 fields, Freeman's Farm Overlook and The Great Redoubt, Saratoga National Historical Park, New York (SNHP). During the growing season of 1988, permanent line transects were established on both fields. Permanent quadrats (20 x 100 cm) were established on the transects, and vegetation within these quadrats was sampled in July and August 1988. Frequency data for each species occurring in the quadrats were calculated. The burned fields were sampled in August, 1992, and the vegetation on burned sites was compared with that on the preburned (1988) data. Fire apparently had little influence on the total numbers of species in both fields. The total number of woody species on the Freeman Farm Field decreased from 9 to 4 and from 12 to 7 on the Great Redoubt Field. Thirty nine percent of the species in these fields are not native to the United States.

## INTRODUCTION

Saratoga National Historical Park (SNHP), comprising 1088 ha, is located in Saratoga County New York (latitude 43 00'; longitude 73 38')[2]. The Park is the site of the Battles of Saratoga, 1777, which resulted a major defeat of the British army[6]. The Park is mandated to restore and maintain the historic landscape of the battle field as it looked in 1777. Exotic vegetation in the fields of SNHP have been designated for control management action to help restore the Park's historic quality. The objective of the present study is to compare species composition on burned and preburned portions of 2 fields, Freeman's Farm Overlook, a field comprising 3.2 ha and the Great Redoubt, a field comprising 7.3 ha, over a four year period, 1988 to 1992. Geology soils and climate of SNHP have been discussed in detail in earlier papers [5,6].

## METHODS

During the growing season of 1988, permanent line transects were established in the above two fields at SNHP. Transects originate at mile markers on the edge of the park road and extend into the fields following a predetermined compass line so that the transects are perpendicular to their point of origin. Permanent quadrats (20 x 100 cm) have been established on the transects at 5 m intervals beginning at a point 10 m from the edge of the road following the procedure of Stalter and Lynch (1991)[7].

1/ Dept. of Biology St. John's University, Jamaica, N.Y. 11439
2/ Saratoga National Historical Park, Stillwater, N.Y. 12170

Vegetation in the aforementioned fields was sampled by the quadrat method in July and August, 1988. Frequency data, percent quadrats occupied for each species occurring in the quadrats in each field, was calculated. The vegetation data obtained in July-August 1988 serves as base line data for the present study, a comparison of pre-burned and burned fields 1988-1992. Woody vegetation on Freeman's Farm Overlook site was burned in 1989 and 1991 during late March and early April. Woody vegetation on The Great Redoubt site was cut by hand in 1986 and 1990. The Great Redoubt site was burned in 1988, 1990 and 1992 during late March-early April. The two study sites are burned following the techniques of Niering and Goodwin (1974)[3]. Fields were sampled in August 1992. We compare the effects of burning on species composition of two fields over a four year period, 1988-1992 (Table 1). Nomenclature follows that of Gleason and Cronquist (1991)[1].

## RESULTS AND DISCUSSION

### Freeman's Farm Overlook

Twenty five species were observed on the Freeman's Farm Overlook Field, in 1988, while 28 were observed in 1992, an increase of three species. Fifteen similar species were observed in both 1988 and 1992 (similarly coefficient of 0.57). Nine woody species were present in 1988, 36% of the total, while only 4 woody species were observed in 1992, a significant decrease. Five new herbaceous plants were observed in 1992. Eight new non native species were observed within the quadrats in 1992. The percentage of non native species increased from 20 percent in 1988 to 52 percent of the total in 1992. The total number of non native plants increased from 5 to 13, a significant increase. Centaurea spp. increased from 53% to 67% over the four year period. Galium verum, Fragaria virginiana, Carex spp. Lotus corniculatus and Toxicodendron radicans increased by 20 percent or more over the 4 year period. Rumex acetosella and Parthenocissus quinquefolia decreased from 27 and 20 percent, respectfully, to 0%.

### The Great Redoubt

Thirty two species were observed within the quadrats on the Great Redoubt Field in 1988. Twenty-nine species were observed in 1992. Twelve woody species were observed in 1988; seven were observed in 1992 (Table 1). Non-native species declined from seven in 1988 to five in 1992. The similarity coefficient comparing in 1988 and 1992 data is high (S = 75 percent). Species apparently favored by burning are Daucus carota which increased from 0 to 47%, Solidago spp. (13 to 73%), Aster spp. (53 to 73%) and Plantago rugelii (0-27%). Cornus racemosa decreased (60 to 47%) as did Rubus flagellaris (73 to 53%) and Fragaria virginiana (67 to 47%).

It is impossible to separate the effect of cutting and fire on species composition at the Great Redoubt Field. No conclusions can be drawn as to which played a greater role on species composition here. Fragaria virginiana increased by thirty percent at Freeman's Farm, but decreased by 20 percent on The Great Redoubt. Centaurea spp. and Cornus racemosa had similar changes (Table 1).

Fire apparently has reduced the number of woody species in both fields, results similar to those observed by Niering and Goodwin (1974) and Niering (1983) on burned fields at the Connecticut Arboretum at Connecticut College, Connecticut. Thus the long term field management objectives at SNHP, to reduce the numbers and dominance of woody species, has been achieved.

A second objective, the reduction of exotic (i.e. non native) species from fields at SNHP appears to have been compromised. The number of exotic species has increased from five to thirteen on Freeman's Farm but decreased from seven to five on The Great Redoubt Field. These data may be somewhat misleading as at least 50 percent of the exotics on both fields were observed in but one quadrat (Table 1). Moreover, native species, i.e., asters, and goldenrods have increased in The Great Redoubt Field.

Results from the present study suggest that a four year interval may be too short a time period to measure the effectiveness of fire as a management tool i.e., an effective control of non native species such as Centaurea spp. and/or favoring native grasses such as Schizachyrium scoparium. Niering's (1983)[4] data indicate that at least ten years of periodic burning is needed to stimulate native grasses at the expense of alien species e.g., Centaurea spp. Four years of burning appears to have increased the number of alien species, especially in the Freeman's Farm Overlook Field where the number of herbeceous alien plants has more than doubled. The number of woody species has decreased. Long-term fire management may be needed to stimulate the growth of native plants such as Schizachyrium scoparium at the expense of non native species.

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TABLE 1. Frequency data for species on permanent quadrats on two fields: Freeman's Farm Overlook; The Great Redoubt, SNHP, NY. 1988 data on unburned fields; 1992 data burned fields. An asterisk (*) proceeds weedy non-native species. A dash (-) indicates the species never was observed within the permanent quadrats at a particular field.

| | STUDY SITE | | | |
|---|---|---|---|---|
| | Freeman's Farm | | Great Redoubt | |
| SPECIES | 1988 | 1992 | 1988 | 1992 |
| *Centaurea spp. | 40 | 33 | 53 | 67 |
| Potentilla simplex | 20 | 13 | 33 | 33 |
| Cornus racemosa | 60 | 47 | 13 | 20 |
| Schizachyrium scoparium | 47 | 47 | 7 | 0 |
| *Daucus carota | 0 | 47 | 0 | 7 |
| Solidago spp. | 13 | 73 | 13 | 13 |
| Aster spp. | 53 | 73 | 7 | 7 |
| *Hieracium spp. | 7 | 0 | - | - |
| Rhus glabra | 27 | 20 | - | - |
| Equisetum arvense | 27 | 20 | 13 | 27 |
| Rubus flagellaris | 73 | 53 | 7 | 0 |
| Galium verum | 7 | 27 | 60 | 87 |
| Fragaria virginiana | 67 | 47 | 13 | 47 |
| *Rumex acetosella | 7 | 13 | 27 | 0 |
| Vitis aestivalis | 13 | 20 | - | - |
| *Achillea millefolium | 7 | 13 | 0 | 7 |
| *Melilotus officinalis | 7 | 0 | - | - |
| Ulmus americana | 7 | 0 | 7 | 0 |
| Carex spp. | 27 | 27 | 7 | 27 |
| Rubus occidentalis | 7 | 0 | 7 | 0 |
| Oxalis stricta | 20 | 27 | 7 | 0 |
| Hamamelis virginiana | 7 | 7 | - | - |
| Ranunculus spp. | 13 | 13 | 0 | 13 |
| Rudbeckia hirta | 7 | 13 | 0 | 7 |
| Prunus serotina | 7 | 13 | - | - |
| Rubus hispidus | 7 | 0 | - | - |
| Rubus allegheniensis | 20 | 0 | 20 | 27 |
| Rhus typhina | 7 | 0 | - | - |
| Geranium maculatum | 20 | 0 | - | - |
| Galium aparine | 7 | 7 | - | - |
| *Celastrus orbiculatus | 7 | 0 | - | - |
| *Prunella vulgaris | 7 | 7 | 0 | 13 |
| Fraxinus americana | 7 | 7 | - | - |
| Toxicodendron radicans | - | - | 33 | 53 |
| Sambucus canadensis | - | - | 7 | 0 |
| Asclepias syriaca | - | - | 7 | 7 |
| Parthenocissus quinquefolia | - | - | 20 | 0 |
| *Glechoma hederacea | - | - | 7 | 0 |
| *Hypericum perforatum | - | - | 7 | 0 |
| *Linaria vulgaris | - | - | 13 | 7 |
| Robinia pseudoacacia | - | - | 7 | 7 |
| *Chrysanthemum leucanthemum | 0 | 7 | - | - |
| *Potentilla recta | 0 | 7 | - | - |
| *Thymus serpyllum | 0 | 7 | - | - |
| Plantago rugelii | 0 | 7 | 0 | 7 |
| *Vicia tetrasperma | - | - | 0 | 7 |
| *Calystegia sepium | - | - | 0 | 7 |
| *Veronica spp. | - | - | 0 | 7 |
| *Medicago sativa | - | - | 0 | 7 |
| *Lotus corniculatus | - | - | 0 | 20 |
| *Trifolium pratense | - | - | 0 | 13 |
| *Trifolium aureum | - | - | 0 | 7 |
| *Vicia dasycarpa | - | - | 0 | 7 |

# HOW DEER BROWSING CREATES VEGETATION MANAGEMENT PROBLEMS IN ALLEGHENY HARDWOOD FORESTS

Stephen B. Horsley[1]

## ABSTRACT

Browsing by white-tailed deer (Odocoileus virginianus virginianus (Boddaert)) has been one of the most important factors shaping northwestern Pennsylvania's Allegheny hardwood forest in this century. Not only have deer effected the abundance and rate of growth of forest vegetation, but also due to the selective nature of browsing, species composition as well. Advance seedlings are an important source of regeneration in the Allegheny hardwood forest. These seedlings frequently fail to become established in the presence of dense ground covers of hayscented (Dennstaedtia punctilobula (Michx.) Moore) and New York fern (Thelypteris noveboracensis L.), grasses and sedges or understories of striped maple (Acer pensylvanicum L.) and American beech (Fagus grandifolia Ehrh.). To evaluate the role of deer and forest cutting on forest vegetation, we studied changes in the herbaceous and woody plants at four 160 acre sites for 10 years in a large enclosure study where deer were maintained at densities of 0, 10, 20, 38 and 64 animals/sq mi. At each site, 10% of the area was clearcut, 30% was thinned and 60% remained uncut. The study showed that some browsing effects occurred through direct removal of vegetation; in other cases deer browsing set in motion density-dependent plant-plant interactions which over time resulted in changes in species composition. Three examples of deer density-dependent plant-plant interactions were encountered in thinned stands. First, there was a strong relationship between the % ground cover by Rubus (Rubus allegheniensis Porter and Rubus occidentalis L.), a palatable species, and deer density; the higher the deer density, the lower the % ground cover by Rubus. Rubus in turn influenced the % ground cover by hayscented and New York fern, species not palatable to deer which strongly interfere with survival and growth of black cherry (Prunus serotina Ehrh.) and other Allegheny hardwood species. Where % ground cover by Rubus was high, % ground cover by ferns remained low, but where deer removed Rubus, fern cover increased. Second, deer density determined which tree species dominated thinned stands. At two sites, black cherry and birch (Betula alleghaniensis Britt. and Betula lenta L.) were the dominant species. Birch, which is more palatable to deer and more tolerant of shade than black cherry, outgrew black cherry and was the dominant stem 10 years after thinning at densities less than 38 deer/sq mi. However, at 64 animals/sq mi deer consumed most of the birch, resulting in dominance of 90% of the regeneration sample plots by black cherry. At the other two sites, striped maple, a browse resistant, very shade tolerant species dominated 65-80% of the regeneration sample plots at the beginning of the study. This dominance was maintained through 10 years. Other species were suppressed beneath striped maple. Ferns, birch and striped maple are not considered desirable species in the Allegheny hardwood type. Thus, some form of vegetation management will be necessary to maintain desirable species where deer density drives forest vegetation toward an unwanted outcome.

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# CROWN REDUCTION OF SELECTED BRUSH AND CONIFER SPECIES TO GLYPHOSATE HERBICIDE AND POEA SURFACTANT RATES

G. Richard Schaertl[1] and Maxwell L. McCormack, Jr.[2]

## ABSTRACT

An experiment was conducted to evaluate the relationship between application times, herbicide rates, and surfactant rates on reducing crown size (%). Four rates (0, 1, 2, 3 lb/A a.i.) of IPA glyphosate (Accord®), and four rates (0,10, 20, 30 ozfl/A) of formulated polyoxyethyleneamine (POEA) surfactant (Entry™ II) were aerially applied in 5 gpa aqueous solution on 22-23 August and 12-13 September 1989 to 50 ft by 700 ft plots located in a seven year old clearcut in Bradley Township, Maine. The factorial study used a completely randomized block design with two replicates. Conifers were saplings of balsam fir [Abies balsamea (L.) Mill.], spruce (Picea A. Dietr), eastern white pine (Pinus strobus L.). Brush were saplings of birch (Betula L.), stump sprouts of red maple (Acer rubrum L.), and mature common red raspberry (Rubus idaeus L.). Observations were made one year after treatment. Analysis of variance was performed with $p \leq 0.05$.

Crowns of spruce and fir were not affected significantly by any treatment. Pine crowns were significantly reduced 2% from the early application. Except for raspberry, the early application was more efficacious for brush species. Crowns of brush species decreased with increasing rates of glyphosate and POEA. However, the differences were not always statistically significant. Crowns of red maple decreased significantly from 10%, 28%, and 46% only by increasing glyphosate from 0, 1, and 3 lb/A ai, respectively.

Birch crowns were significantly affected by application time, glyphosate rates, and the interaction of time and glyphosate rate. The early application decreased crowns 70%, 14% more than the late application (Table 1). Increasing glyphosate from 0 to 1 and 2 lb/A ai reduced birch crowns from 9% to 68% and 86%, respectively. Crown reduction from the 3 lb/A ai rate was not significantly different than the 2 lb/A ai rate. The difference in crown reduction between 1 lb/A and pooled 2 and 3 lb/A of glyphosate was 13% more with the late application than the early application.

Raspberry crowns were significantly reduced by application time, glyphosate rate, and the interaction of time, glyphosate rate, and POEA rate. The late application decreased raspberry crowns 46%, 12% more than the early application. Increasing glyphosate to 3 lb/A ai reduced raspberry crowns by 23% or more over 0 and 1 lb/A. The 2 and 3 lb/A rates reduced raspberry crowns by 44% or more over no glyphosate.

In summary, crowns of brush species decreased significantly with increasing rates of glyphosate. Adding POEA to glyphosate also tended to decrease crowns, but not significantly. The early application resulted in significant crown reduction of deciduous tree species. However, raspberry crowns were decreased more by the late application.

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Table 1. Crown reduction (%) of birch and common red raspberry from two application dates by four rates of glyphosate by four rates of POEA surfactant. Application 1 occurred on 22,23 August, 1989. Application 2 occurred on 12,13 September, 1989.

| Application | POEA[a] (ozfl/A) | Glyphosate[b] (lb/A ai) | | | | Pooled POEA |
|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | |
| **Crown Reduction (%)** | | | | | | |
| **Birch** | | | | | | |
| 1 | 0 | 8 | 83 | 88 | 87 | 66 |
| | 10 | 14 | 78 | 94 | 96 | 71 |
| | 20 | 36 | 68 | 100 | 92 | 74 |
| | 30 | 2 | 89 | 91 | 98 | 70 |
| 2 | 0 | 5 | 57 | 80 | 85 | 57 |
| | 10 | 7 | 53 | 80 | 86 | 57 |
| | 20 | 3 | 55 | 67 | 89 | 53 |
| | 30 | 1 | 57 | 83 | 94 | 59 |
| Glyphosate x POEA | 0 | 6 | 70 | 83 | 86 | 64 |
| | 10 | 11 | 66 | 87 | 91 | 64 |
| | 20 | 19 | 62 | 84 | 90 | 64 |
| | 30 | 2 | 73 | 87 | 96 | 62 |
| Application 1 x Glyphosate | | 15 | 79 | 93 | 93 | 70 |
| Application 2 x Glyphosate | | 4 | 56 | 78 | 88 | 56 |
| Pooled Glyphosate | | 9 | 68 | 86 | 91 | |
| **Common Red Raspberry** | | | | | | |
| 1 | 0 | 11 | 42 | 43 | 75 | 43 |
| | 10 | 11 | 49 | 53 | 44 | 39 |
| | 20 | 10 | 33 | 53 | 73 | 42 |
| | 30 | 4 | 55 | 82 | 97 | 60 |
| 2 | 0 | 5 | 22 | 45 | 32 | 26 |
| | 10 | 5 | 23 | 51 | 63 | 35 |
| | 20 | 6 | 35 | 46 | 69 | 39 |
| | 30 | 7 | 58 | 38 | 38 | 35 |
| Glyphosate x POEA | 0 | 8 | 32 | 44 | 54 | 35 |
| | 10 | 8 | 36 | 52 | 53 | 37 |
| | 20 | 8 | 34 | 49 | 71 | 41 |
| | 30 | 6 | 56 | 61 | 68 | 47 |
| Application 1 x Glyphosate | | 9 | 45 | 58 | 73 | 34 |
| Application 2 x Glyphosate | | 6 | 34 | 45 | 51 | 46 |
| Pooled Glyphosate | | 7 | 39 | 51 | 62 | |

[a]POEA surfactant formulated as Entry II. [b]Glyphosate formulated as Accord.

# MILE-A-MINUTE CONTROL ON HARVESTED FOREST SITES

Larry H. McCormick and Nathan L. Hartwig[1]

## ABSTRACT

Mile-a-minute is an aggressive annual vine introduced from eastern Asia that is rapidly colonizing non-crop areas in portions of Pennsylvania, Maryland, West Virginia, Delaware and Virginia. In southcentral Pennsylvania where many of the forest sites are heavily infested with mile-a-minute, mile-a-minute is interfering with forest regeneration. Following overstory removal and site preparation, dense communities of mile-a-minute become established and dominate the site by overtopping existing or planted tree seedlings. The dense shade created by the vine's canopy reduces seedling growth and often results in seedling mortality. Unfortunately not much is known about the control of this noxious weed.

A study was conducted in 1992 to evaluate the ability of several herbicides to control mile-a-minute, *Polygonum perfoliatum* L., on forest sites. Ten herbicide treatments, atrazine at 2 and 4 lb/A (AAtrex Nine-O at 2.2 and 4.4 lb/A); hexazinone at 0.5 and 1 lb/A (Velpar L at 1 and 2 qt/A); sulfometuron methyl at 1.5 and 3 oz/A (Oust at 2 and 4 oz/A); sulfometuron methyl + hexazinone at 1.5 oz + 0.5 lb/A (Oust + Velpar L at 2 oz + 1 qt/A); glyphosate at 1 lb/A (Roundup 1 qt/A); imazethapyr at 0.0625 lb/A (Pursuit at 0.25 pt/A); imazethapyr + pendimethalin at 0.0625 + 0.875 lb/A (Pursuit Plus at 1.25 qt/A), were applied preemergence (March 9) and postemergence (June 11) to mile-a-minute growing on a recently harvested forest site in southern York County, PA. The pre- and postemergence evaluations were conducted as separate trials with each employing a randomized block design with three replications (25 x 25 ft. plots). Visual estimates of percent control of mile-a-minute and percent groundcover by all vegetation were made on July 2 and August 12, 1992 for both trials.

The results showed that AAtrex Nine-O (2.2 and 4.4 lb/A) and Velpar L (1 and 2qt/A) were the most effective (90-100% control) postemergence treatments for controlling mile-a-minute. Initially the Oust (2 and 4 oz/A), Roundup (1 qt/A), Pursuit (0.25 pt/A) and Pursuit Plus (1.25 pt/A) treatments also appeared to provide good postemergence control of mile-a-minute, however, by the time of the second evaluation many of the mile-a-minute plants in these treatments had resprouted and were actively growing and setting fruit. All of the herbicide treatments except AAtrex Nine-O (2.2 lb/A) and Roundup appeared to provide good preemergence control of mile-a-minute, however, a low and spotty occurence of mile-a-minute in the preemergence test area made it difficult to draw reliable conclusions about the preemergence efficacy of these treatments.

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# A PHOTOGRAPHIC TECHNIQUE FOR EVALUATION OF MATURE TREE CROWN GROWTH

**John R. Seiler and Paul N. McBee[1]**

## ABSTRACT

To adequately test the effectiveness of tree growth regulators, as well as other factors which impact mature tree crown growth (e.g., pruning, fertilization, or loss of vigor), a reliable and repeatable method to estimate crown size is needed. We evaluated a simple, rapid photographic technique for estimation of projected tree crown area. The technique utilizes photographs of tree crowns taken from two or more directions with an object of known scale present in each photograph. The photographs are then displayed onto a dot grid and the projected (two-dimensional) crown surface area in square feet estimated. Total height, crown width, and live crown length can also be estimated from the photographs. The estimates obtained from the photographs agree well with on-ground measurements of height and crown width. The average percent error for crown width and height estimates were 1.8 and 3.2 percent, respectively. The technique is most accurate when used on trees with a clear view on two sides, which limits its use in some urban settings such as closely planted rows of trees. With this technique, reductions in growth due to pruning, growth regulator application, or loss of vigor can be accurately and precisely quantified.

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# CRABGRASS CONTROL IN 1992

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## ABSTRACT

A preemergence study and a postemergence study conducted in 1992 are summarized below.

Preemergence Study

The preemergence herbicides in this study were applied at 75 gpa using a $CO_2$-backpack sprayer equipped with a two nozzle boom. Plots were 3 by 10 feet and were arranged in a randomized complete block with three replications. The study site was core cultivated, grooved, and overseeded with locally harvested crabgrass (Digitaria spp.) in the fall of 1991. Excellent crabgrass pressure was present in all three replications and percent control was rated on August 21, 1992. The site was comprised of a mixture of Kentucky bluegrass (Poa pratensis L.), perennial ryegrass (Lolium perenne L.), and fine fescue (Festuca spp.).

Most treatments were applied on May 7 or May 9 with the exception of bensulide which was applied at 7.5 lbs a.i./A on May 11. Not only was the bensulide rate too low, the timing was too near the date of germination (May 13); and as a result, control was not acceptable (greater than 85%).

Prodiamine (0.65 lbs a.i./A), benefin (1.5 + 1.5 lbs a.i./A eight weeks later), benefin + trifluralin (3 lbs a.i./A and 1.5 + 1.5 lbs a.i./A eight weeks later), FN 9064 (250 and 375 lbs product/A), pendimethalin (1.5 lbs a.i./A and 1.5 + 1.5 lbs a.i./A), dithylopyr (0.375 and 0.5 lbs a.i./A), dithiopyr + oxadiazon (0.125 + 2.0 lbs a.i./A), dithiopyr + oxadiazon (0.25 + 1.0 lbs a.i./A), dithiopyr + oxadiazon (0.25 + 2.0 lbs a.i./A), dithiopyr + oxadiazon (0.125 + 1.0 lbs a.i./A), MON-25134 (0.125, 0.187, 0.25, and 0.375 lbs a.i./A), EXP. 30742B (5 and 6 lbs a.i./A), EXP. 30909A (5 lbs a.i./A), EXP. 30910A (5 and 6 lbs a.i./A), EXP. 30925A (5 lbs a.i./A), benefin (2 lbs a.i./A), and DCPA (10.5 lbs a.i./A) all provided acceptable control.

Injury was rated on June 30 and August 21. Fine fescue was the species in the mixture that was injured (stand loss or thinning). On June 30, benefin + trifluralin (Team) at 3.0 lbs a.i./A caused 25% fine fescue thinning and at 2.0 lbs a.i./A caused 17% thinning. The Team split application at 1.5 followed by 1.5 eight weeks later caused less than 5% thinning. FN 9064 at 375 and 250 lbs product/A caused 35 and 15% thinning, respectively. The only other compound that caused 10% or greater thinning was oxadiazon at 4 lbs a.i./A. By August 21, only fine fescue that had been treated with the high rate of FN 9064 had not completely recovered.

Postemergence Study

The post or combination pre/post herbicides in this study were applied at 40 gpa using a $CO_2$-backpack sprayer equipped with a two nozzle boom. Treatments were applied on July 14 when most crabgrass plants were approximately four leaf stage with some beginning to tiller. The site was comprised of the same species and crabgrass introduced into the site in the same manner as in the preemergence study.

Dithiopyr at 0.38 and 0.5 lbs a.i./A, fenoxaprop at 0.25 lbs a.i./A, HOE-360-18H at 0.09 lbs a.i./A, HOE 360-08H at 0.09, 0.12, and 0.18 lbs a.i./A, MSMA at 2.0 lbs a.i./A followed by 2.0 lbs a.i./A two weeks later, the combination of dithiopyr and fenoxaprop at 0.38 and 0.18 lbs

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a.i./A, respectfully, prodiamine plus fenoxaprop at 0.5 and 0.18, respectfully, prodiamine plus MSMA at 0.5 and 2.0 lbs a.i./A, respectfully, benefin plus fenoxaprop at 2.0 and 0.18 lbs a.i./A, respectfully, pendimethalin plus fenoxaprop at 1.5 and 0.18 lbs a.i./A, respectfully, and prodiamine plus quinclorac at 0.5 and 0.75 lbs a.i./A, respectfully controlled crabgrass better than 85%. Only fenoxaprop at 0.12 and 0.18 lbs a.i./A, HOE 360-08H at 0.06 lbs a.i./A, and quinclorac at 0.75 lbs a.i./A did not control crabgrass 85% or greater, although quinclorac and fenoxaprop did provide 78 and 83% control, respectfully. The only injury observed was caused by the two week repeat application of MSMA. The injury was a slight but temporary discoloration.

# EVALUATION OF PREEMERGENCE HERBICIDES FOR SMOOTH CRABGRASS CONTROL IN MARYLAND, 1992

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## ABSTRACT

Three studies were conducted to evaluate commercial and experimental herbicides for their preemergence control efficacy of smooth crabgrass[Digitaria ischaemum (Schreb.) Muhl.]. The products and rates evaluated and dates of herbicide applications are described below or summarized in data tables. Granular herbicides were applied with a shaker bottle and sprayables were applied with a $CO_2$ pressurized (36 psi) sprayer (8004E nozzle) calibrated to deliver 50 gpa. Study areas were irrigated within 24 hours of treatment. All studies were arranged as a randomized complete block with four replications, and plots were 5 by 5 ft. Study sites were mature stands of 'Fylking' or 'Kenblue' Kentucky bluegrass (Poa pratensis L.) maintained at 1.5 inches. Soil was a Chillum silt loam with a pH of 6.2 to 6.4, and 2.4 to 2.7% organic matter. Although smooth crabgrass seedlings were first observed 27 April 1992, major germination did not begin until June, continued throughout July, and subsided by 10 August 1992. Percent of plot area covered by smooth crabgrass was visually determined on a 0 to 100% linear scale on 10 July and again between 22 to 25 August 1992. Although percent of control ≥90 is considered excellent, crabgrass cover ratings exceeding 5% would be considered objectionable in professionally managed turfgrasses. Significantly different means were separated by Duncan's multiple range test at P = 0.05.

In Study I, various rates of two formulations of dithiopyr were applied on 8 April 1992, and one treatment was applied early postemergence on 8 June 1992. Nearly all treatments (dithiopyr 1EC at 0.38 and 0.50 lb ai/A; MON 25134 0.1G at 0.187, 0.250, and 0.375 lb ai/A; and Barricade 65DG at 0.65 lb ai/A) provided ≥94% control. MON 25134 0.1G (0.125 lb ai/A), however, provided marginally acceptable control. Dithiopyr 1EC (0.5 lb ai/A) applied postemergence when crabgrass in the 1 to 4-leaf stage provided 99% season-long control.

In Study II, two formulations of oxadiazon and several experimental herbicides were evaluated (Table 1). Preemergence treatments were applied either on 17 March or 1 April 1992. Due to heavy smooth crabgrass germination throughout June and July, many treatments provided less than 90% control. Ronstar (4.0 lb ai/A) applied 17 March provided less control (78 - 79%) than counterpart Ronstar treatments (89 - 95%) applied 1 April. Ronstar Biodac formulation was slightly more efficacious than the clay formulation when applied on 1 April. Excellent control (i.e. >90%) was provided by EXP 30742B 2.3G (5.0 lb ai/A); EXP 30909A 4G (5.0 lb ai/A); and Pre-M 60DG. Superior control (i.e. ≤5% crabgrass cover) was achieved by Ronstar 2G (Biodac) + Dimension (2.0 + 0.125 lb ai/A); EXP 30742B 2.3G (6.0 lb ai/A); EXP 30910A 5G (6.0 lb ai/A); and Ronstar 2G (Biodac; 4.0 lb ai/A).

In Study III, various commercially available preemergence herbicides were evaluated. Corn speedwell (Veronica arvensis L.) emerged in the study site following herbicide application on 8 April 1992. Excellent preemergence control of speedwell was provided by Gallery + Team; Dimension products; Barricade 65DG (0.65 lb ai/A); and Dacthal 6F. Ronstar 2G (Biodac; 4.0 lb ai/A) and Team 2G also provided very good speedwell control. None of the herbicides injured or discolored the turfgrass, and turf color was improved by granular products formulated with fertilizer. Again, due to heavy smooth crabgrass germination throughout June and July, most herbicides provided less than 90% control. Excellent control was provided by Lebanon Dimension (0.31 lb ai/A) and Gallery + Team 1.09G. Superior control was provided by Ronstar 2G (Biodac; 4.0 lb ai/A) and Lebanon Dimension 0.09G (0.38 lb ai/A). Most other treatments provided good season-long control. However, very poor control (i.e. ≤75%) was associated with Balan 2.5G; Dimension (0.38 lb ai/A); Lescosan 4EC; and Dacthal 6F.

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Table 1. Preemergence smooth crabgrass (Digitaria ischaemum) control in 'Fylking' Kentucky bluegrass with oxadiazon and experimental herbicides. Study II.

| Herbicide† | Rate (lb ai/A) | Smooth Crabgrass Cover 10 Jul | Smooth Crabgrass Cover 25 Aug | Smooth Crabgrass Control 25 Aug |
|---|---|---|---|---|
| | | % | | |
| Ronstar 2G (Clay) | 4.0‡ | 1b¶ | 17bc | 79 |
| Ronstar 2G (Biodac) | 4.0‡ | 1b | 18bc | 78 |
| Ronstar 2G (Clay) | 2.0 | 1b | 18bc | 78 |
| Ronstar 2G (Clay) | 4.0 | <1b | 9bcde | 89 |
| Ronstar 2G (Biodac) | 2.0 | <1b | 16bcd | 80 |
| Ronstar 2G (Biodac) | 4.0 | 0b | 4cde | 95 |
| EXP 30742B 2.3G | 5.0 | <1b | 7bcde | 91 |
| EXP 30742B 2.3G | 6.0 | <1b | 2de | 98 |
| EXP 30909A 4G | 5.0 | 0b | 5cde | 94 |
| EXP 30910A 5G | 5.0 | <1b | 18bc | 78 |
| EXP 30910A 5G | 6.0 | 0b | 4cde | 95 |
| EXP 30910A 5G + EXP 30910A 5G | 3.0 + 2.0§ | 1b | 10bcde | 88 |
| EXP 30925A 6G | 5.0 | 1b | 21b | 74 |
| Ronstar 2G (Biodac) + Dimension 0.1G | 1.0 + 0.125 | 0b | 10bcde | 88 |
| Ronstar 2G (Biodac) + Dimension 0.1G | 2.0 + 0.125 | 0b | 1e | 99 |
| Pre-M 60DG | 3.0 | 0b | 5cde | 94 |
| Untreated | --- | 8a | 82a | --- |

†Herbicides were applied on 1 Apr 1992 except as otherwise noted.
‡Herbicides were applied on 17 Mar 1992.
§Herbicide was applied sequentially on 29 May 1992.
¶Means in a column followed by the same letter are not significantly different at P = 0.05 level according to Duncan's MRT.

Table 2. Preemergence smooth crabgrass (Digitaria ischaemum) control in 'Kenblue' Kentucky bluegrass. Study III.

| Herbicide† | Rate (lb ai/A) | Speedwell Cover‡ 18 May | Turf color 18 May | Smooth Crabgrass Cover 10 Jul | Smooth Crabgrass Cover 25 Aug | Smooth Crabgrass Control 25 Aug |
|---|---|---|---|---|---|---|
| | | (%) | (0-10 scale) | % | | |
| Ronstar 2G (Biodac) | 4.0 | 8de§ | 7.5cde | 0b | 3g | 97 |
| Lebanon Dimension 0.09G (Fert.) | 0.25 | 5ef | 7.7bcd | 0b | 11efg | 88 |
| Lebanon Dimension 0.09G (Fert.) | 0.31 | 2f | 7.9abc | 0b | 8fg | 91 |
| Lebanon Dimension 0.09G (Fert.) | 0.38 | <1f | 8.2a | 0b | 3g | 97 |
| Team 2G | 1.5 + 1.5 | 3f | 7.3de | <0.5b | 15dfg | 84 |
| Balan 2.5G | 2.0 + 2.0 | 15bc | 7.3de | <0.5b | 25cde | 73 |
| Lesco Team 1.15G (Fert.) | 1.5 + 1.5 | 12cd | 8.0ab | 0b | 10fg | 89 |
| Lesco Pre-M 0.86G (Fert.) | 1.5 + 1.5 | 18ab | 8.0ab | <0.5b | 12efg | 87 |
| Gallery + Team 1.09G (Fert.) | 4.1 | 0f | 8.2a | 0b | 9fg | 90 |
| Dimension 1EC | 0.38 | 0f | 7.7bcd | 0b | 34c | 63 |
| Dimension 1EC | 0.50 | 0f | 7.3de | 0b | 13dfg | 86 |
| Barricade 65DG | 0.50 | 1f | 7.2e | 0.5b | 20def | 78 |
| Barricade 65DG | 0.65 | 0f | 7.3de | <0.5b | 11efg | 88 |
| LescoSan 4EC | 12.0 | 16bc | 7.5cde | 1b | 60b | 34 |
| Dacthal 6F | 10.5 + 5.2 | 0f | 7.6bcde | 0b | 26cd | 71 |
| Untreated | --- | 21a | 7.3de | 17a | 91a | --- |

†Herbicides were applied on 8 Apr 1992; sequential treatments were applied 20 May 1992.
‡Corn speedwell (Veronica arvensis L.).
§Means in a column followed by the same letter are not significantly different at P = 0.05 level according to Duncan's MRT.

# SMOOTH CRABGRASS SEED SOURCE AND GROWTH STAGE EFFECTS ON QUINCLORAC EFFICACY

S. J. Koo and J. C. Neal[1]

## ABSTRACT

Quinclorac efficacy on smooth crabgrass [*Digitaria ischaemum* (Schreb. ex Schweig) Schreb. ex Muhl] has been shown to be affected by several factors such as drought, irrigation schedule, spray coverage, and smooth crabgrass biotype and growth stage. This year, smooth crabgrass seed source and growth stage effects were further examined in greenhouse and field tests.

In greenhouse experiments, three seed sources, collected in Ithaca, New York, Marysville, Ohio, and Kingston, Rhode Island, were compared in three growth stages, young seedling (2- to 3-leaf), early tillering (1- to 3-tillers), and mid-tillering (5- to 6-tillers) stage. In two field tests in Ithaca, New York, native crabgrass was treated at the same growth stages. Quinclorac (75% DF) was sprayed at rates of 0, 120, 250, 500, 750, and 1,000 g ai $ha^{-1}$ using a $CO_2$-pressurized backpack sprayer calibrated to deliver 280 L $ha^{-1}$ in both greenhouse and field experiments. In the greenhouse experiment, shoot fresh weight was measured 2 and 4 weeks after treatment (WAT). In the field experiments, herbicidal efficacy was visually evaluated at one week intervals. The final visual evaluation was made in early October, after the first frost. Using regression analysis, rates to achieve 50 and 90 % control ($I_{50}$ and $I_{90}$) were calculated.

In the greenhouse tests, $I_{50}$s were similar for all three biotypes at all the growth stages tested. For the Ohio and Rhode Island biotypes, $I_{90}$s also tended to be stable across growth stages. In contrast, the $I_{90}$ for the New York biotype increased as growth stage advanced. In summary, greenhouse experiments showed that susceptibility of three biotypes was similar up to early tillering stage, and that New York biotype was somewhat more tolerant than others at mid-tillering stage.

In the field, the New York biotype showed stable $I_{50}$s and increasing $I_{90}$s at advanced growth stages up to 6 WAT, similar to the results from the greenhouse experiments. At 6 WAT, $I_{50}$s were 120, 170, and 170 g ai $ha^{-1}$, and $I_{90}$s were 330, 470, and $>1,000$ g ai $ha^{-1}$ for young seedling, early tillering, and mid-tillering stage, respectively. Tolerance increased remarkably between early and mid-tillering stage. At final evaluation, $I_{50}$s were 260, 130, and 170 g ai $ha^{-1}$, and $I_{90}$s were 640, 410, and $>1,000$ g ai $ha^{-1}$ for young seedling, early tillering, and mid-tillering stage, respectively. Differences in the results between two evaluation times were most pronounced in young seedling stage treatment.

In conclusion, the New York biotype tends to be more tolerant at advanced growth stages both in the greenhouse and field, whereas other biotypes are not. In practical perspectives, early tillering stage treatment provides better long-term control. Young seedling stage treatment does not provide good control through the season possibly due to late germination or poor spray coverage of young seedlings within a dense turf canopy. Late treatment did not provide adequate control.

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# BUTRALIN: A NEW HERBICIDE FOR PREEMERGENCE TURFGRASS WEED CONTROL

T. E. Vrabel, W. F. Evans, and J. E. Merrick[1]

## ABSTRACT

Butralin is the common name for [4-(1,1-dimethyl)-N-(1-methylpropyl)-2,6 dinitrobenzenamine]. It is a member of the dinitroaniline class of herbicides. Butralin has low water solubility and atmospheric volatility and shows excellent herbicidal activity against annual grassy turf weeds. The commercial product, under the trade name CHIPCO® CHOICE®, will be formulated as a 2.3% granule on a low dust recycled paper byproduct carrier. CHIPCO® CHOICE® will be initially registered on warm and cool season turfgrass species for the control of smooth crabgrass (Digitaria ischaemum 'Schreb. ex. Schweig.') DIGIS, large crabgrass (Digitaria sanguinalis L.) DIGSA, goosegrass (Eleusine indica L) ELEIN, and annual bluegrass (Poa annua L.) POANN.

Recommended use rates for application are: 4 to 6 lbs. ai/A for the control of crabgrass species and 6 lbs. ai/A for the control of goosegrass and Poa annua. In the Northern United States and the transition zone, excellent season long crabgrass control can be obtained with the 5 lb. ai/A rate while applications of 6 lbs. ai/A are recommended in the southern U.S. Difficult to control weeds such as goosegrass and Poa annua are best controlled with either sequential applications of CHIPCO® CHOICE® or applications timed to occur just before weed germination. Results of over 50 trials nationwide in the past two years have shown that CHIPCO® CHOICE® will provide annual grassy that is comparable to commercial standards such as pendimethalin.

CHIPCO® CHOICE® when used as directed can be applied to all warm and cool season turfgrass species with the exception of buffalograss (Buchloe dactyloides (Nutt.) 'Engelm.'). It does not injure greens height bentgrass (Agrostis stolonifera L.) and has been shown in root health studies to have the least negative impact on root health of commercial dinitoaniline turfgrass herbicides on species such as Kentucky bluegrass (Poa pratensis L.). Overseeding can be done effectively if delayed until 3 months after application.

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# SMOOTH CRABGRASS CONTROL IN TURF WITH BUTRALIN AND OTHER PREEMERGENCE HERBICIDES

R. B Taylorson[1]

## ABSTRACT

Experiments were conducted in 1991 and 1992 at the University of Rhode Island to evaluate the efficacy of preemergeence applications of butralin formulations and several other herbicides in the control of smooth crabgrass (Digitaria ischaemun (Schreb.) Muhl.). The studies were conducted in an established, but undernourished Kentucky bluegrass (Poa pratensis L.)/red fescue (Festuca spp.) turf mowed at about 2.5 inches. The experimental design was a randomized complete block with four replications of 6 x 10 foot plots. Granular formulations were applied with a drop spreader. In both years, treatments were applied on April 16. Ratings of phytotoxicity to turf and weed control were taken at appropriate intervals as indicated. All herbicide rates are expressed as lb ai/A.

In 1991, butralin was tested in several granular carriers as a 2.3G and as a 4E at rates of 4 & 6 lb. and was compared to oxadiazon (Ronstar 2G) at 2&4 lb and pendimethalin (Pre-M 60 WG) at 3 lb as standards. The results indicated that the EC and vemciculite carriers of butralin were the only formulations to provide season long crabgrass control, but the EC also caused some early-season phytotoxicity. Pendimethalin gave excellent control, but also caused significant injury throughout the season. The results were somewhat affected by a severe mid-season drought.

In 1992, butralin was applied in several Biodac granular formulations only, with varied percent composition and application rates. Standards used were oxadiazon 2G at 2 & 4 lb in clay vs. Biodac formulations, pendimethalin 1.7G at 3 lb, and benefin (Balan 2.5G) at 2 lb. Combination treatments of oxadiazon 2G at 1 & 2 lb with Mon 25134 0.1G at 0.125 lb were also examined. All treatments provided acceptable season-long crabgrass control with minimal turf injury. The highest crabgrass control ratings were provided by both of the oxadiazon granules at 4 lb, butralin 2.3G at 6 lb, butralin 5G at 6 lb, the oxadiazon/Mon 25134 combination at 2 lb of oxadiazon and pendimethalin. Statistically similar control was provided by butralin 2.3G at 5 lb, 4G at 5 lb, and the oxadiazon/Mon 25134 combination at 1 lb of oxadiazon. Less effective treatments were both oxadiazon granules at 2 lb, butralin 5G at 3 lb followed after 6 weeks by another 2 lb, butralin 6G at 5 lb and benefin.

The results demonstrate that granular formulations of butralin can provide safe, effective season-long smooth crabgrass control in cool season grasses provided percent composition and application rates are appropriate.

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# PERFORMANCE OF FERTILIZER AND CLAY GRANULAR FORMULATIONS OF DITHIOPYR IN COOL SEASON TURF

D. C. Riego*, T. E. Dutt, and J. P. Downs [1]

## ABSTRACT

The preemergence and postemergence activity of fertilizer and clay granular formulations of dithiopyr were evaluated on crabgrass (Digitaria spp.) in cool season turf. Seven granular formulations with loadings ranging from 0.086% to 0.207% dithiopyr were evaluated in small, replicated plots and strip trials using shaker bottles, Gandy drop, and rotary spreaders. Rates of 0.06-0.50 lb ai/A were tested in single and sequential applications, and compared to the performance of the standard dithiopyr 1EC formulation.

Single applications of all products provided excellent full season preemergence control of crabgrass. Low rates of 0.06-0.09 lb ai/A applied in sequentials also provided excellent crabgrass control, depending on the area or geography. Performance of the formulations appeared to be impacted by dithiopyr rate, granular particle size, and subsequent granule distribution or coverage. Other factors affecting performance such as dithiopyr release from the various granular formulations cannot be evaluated in these studies.

Other weeds controlled preemergence were goosegrass (Eleusine indica L. Gaertn.), oxalis (Oxalis spp.), spurge (Euphorbia spp.), and others.

All formulations also provided early (1-6 leaf stage, prior to tiller) postemergence crabgrass control. All formulations of dithiopyr evaluated were safe to cool season turf such as bentgrass, Kentucky bluegrass, perennial ryegrass, and tall fescue.

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[1] Industrial, Turf, and Ornamentals Commercial Development, The Agricultural Group of Monsanto Company, Carmel, IN, Bangor, PA, and St. Louis, MO.

# PERENNIAL RYEGRASS SEEDLING TOLERANCE TO DITHIOPYR

H.C. Wetzel and P.H. Dernoeden[1]

## ABSTRACT

Being able to control smooth crabgrass [Digitaria ischaemum (Screb.) Muhl.] at the time of spring establishment is critical in maintaining a dense, quality turfgrass in the Baltimore-Washington D.C. corridor. The objective for this research was to determine when and at what rate dithiopyr 1EC/0.1G could be applied to spring seeded perennial ryegrass (Lolium perenne L.) without causing stand thinning or reduced turfgrass quality.

The study site was seeded on 3 April 1992 to a blend of 'Palmer', 'Prelude', and 'Repell' perennial ryegrass. Seedlings began to emerge in large numbers on 13 April 1992. Various rates of dithiopyr 1EC and 0.1G were applied at two (27 April), four (11 May), and six (27 May) weeks after emergence. The stage of growth of the perennial ryegrass seedlings on the three dates of application were 2 to 3 leaf, 3 to 4 leaf and 4-leaf to 3-tiller; respectively. Turfgrass was initially maintained at 2.25 inches, but mowing height was reduced to 1.5 inches on 7 May 1992. Dithiopyr 1EC was applied in 50 gpa at 36 psi using a $CO_2$ powered backpack sprayer. Dithiopyr 0.1G was applied using a shaker bottle. After each herbicide application, the study area was irrigated. Plots were 5 by 5 feet and arranged in a randomized complete block with four replications. Perennial ryegrass cover and turfgrass quality were visually assessed bimonthly.

All treatments applied two weeks after emergence caused some injury to perennial ryegrass seedlings. Dithiopyr injury primarily took the form of turfgrass thinning, tip-dieback, and yellowing of older leaves. Only dithiopyr 1EC (0.25, 0.38 and 0.50 lb/A) reduced both turfgrass cover and quality. Data collected four and six weeks after treatment (i.e. 26 May and 8 June) indicated that plots treated with the 1EC (0.25, 0.38 and 0.50 lb/A) and 0.1G (0.25 and 0.38 lb/A) formulations were slowly deteriorating. Lowest turfgrass cover and quality was observed on 8 June in plots treated with 1EC (0.25, 0.38 and 0.50 lb/A) and 0.1G (0.25 and 0.38 lb/A). On 26 May and 8 June, however, all herbicide-treated plots exhibited an unacceptable level of quality. Injured turfgrass began to recuperate by 22 June. At that time, acceptable quality was observed in plots treated with 1EC (0.125 lb/A) and 0.1G (0.125 and 0.187 lb/A) formulations. Plots treated with 1EC (0.25 and 0.38 lb/A) or 0.1G (0.38 lb/A) continued to exhibit unacceptable injury; whereas, plots treated with 1EC (0.50 lb/A) were still badly damaged on 22 June.

Dithiopyr applied four weeks after emergence was much less damaging than perennial ryegrass plots treated two weeks after emergence. Two weeks after the 11 May treatment, only the 0.50 lb/A and 0.38 lb/A of the 1EC formulation reduced turfgrass cover and quality; respectively. However, as was previously observed, treated plots of selected 1EC treatments deteriorated over time. Four weeks after the 11 May treatment (i.e. 8 June), both 0.38 and 0.50 lb/A of the 1EC formulation exhibited a reduction in cover and quality. Turfgrass treated with 1EC (0.25 lb/A) and 0.1G (0.38 lb/A) exhibited unacceptable quality (i.e. $<8.0$) on 8 June. Injured turfgrass showed good signs of recuperation by 22 June. Only the 0.50 lb/A rate of 1EC-treated turfgrass had lower cover and quality, when compared to untreated turfgrass. However, 1EC (0.38 lb/A) and 0.1G (0.38 lb/A)-treated plots continued to exhibit unacceptable quality. Hence, perennial ryegrass seedlings were tolerant of 1EC (0.125 and 0.25 lb/A) and 0.1G (0.125, 0.187 and 0.25 lb/A) formulations when applied four weeks after emergence. None of the dithiopyr treatments applied six weeks after emergence on 27 May reduced perennial ryegrass cover or quality when data were collected 2 or 4 weeks after treatment. All plots were last assessed for quality on 25 August. Plots treated with dithiopyr 1EC (0.38 and 0.50 lb/A) two weeks after emergence (i.e. 27 April) still exhibited reduced turfgrass quality. All other herbicide-treated plots had quality rating equivalent to non-herbicide treated plots.

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# EFFECTS OF HERBICIDES ON ROOT DEVELOPMENT IN KENTUCKY BLUEGRASS

**P. C. Bhowmik, G. Baath, B. M. O'Toole[1], and K. Seidler-Lozykowska[2]**

## ABSTRACT

Consecutive annual spring applications of preemergence herbicides may influence the growth and development of turfgrass. The objective of this experiment was to determine the effects of herbicides on root growth and development following preemergence herbicide application. Oxadiazon, EXP30910A, pendimethalin, dithiopyr, benefin, and prodiamine at 4.5, 6.7, 3.4, 0.4, 2.2, and 0.8 kg $ha^{-1}$, respectively, were applied preemergence on May 8, 1992 to large crabgrass [Digitaria sanguinalis (L.) Scop.] on a year-old 'Baron' Kentucky bluegrass (Poa pratensis L.). Treatments were applied to 1 by 3 m plots with a $CO_2$ backpack sprayer at a pressure of 152 kPa in 675 L $ha^{-1}$. The experiment was a randomized completed block design with four replications. Foliar injury to the treated turfgrass was visually rated on a scale of 0 to 100% Stand density was visually rated on a scale of 0 to 9.

Nine 9.5 cm diam metal rings were placed 2.7 cm deep in each plot prior to the preemergence application. Three rings from each plot were removed at 4, 8, and 12 WAT. Rooting strength was determined by lifting wire rings buried beneath turf plugs with an apparatus which used a hydraulic jack powered device. Average psi values from three plugs in each plot reflects the root development following treatment application. Turf plugs were also taken from each plot, and were planted in sand culture in the greenhouse. Root lengths, tiller numbers, and dry weights of roots and tillers were determined after six weeks of growth in the greenhouse.

All treatments controlled large crabgrass effectively 9 WAT. None of the treatments caused any injury to Kentucky bluegrass 4 and 9 WAT. There were no differences in stand density between treatments 9 WAT.

Root growth was normal in all treated plots since no differences in root strength was detected 4 WAT. However, root strength 8 WAT was significantly lower with EXP30910A, pendimethalin, dithiopyr, benefin, and prodiamine than that of the untreated check plot (69 psi). Root strength from the prodiamine (0.8 kg $ha^{-1}$) treated plot was lowest (42 psi) 8 WAT. The root strength in the oxadiazon (4.5 kg $ha^{-1}$) treated plot was equivalent to the strength of the untreated check plot. At 12 WAT, the dithiopyr treated plot resulted in the lowest root strength (42 psi), followed by pendimethalin, benefin, and prodiamine (48 to 49 psi), and oxadiazon and EXP30910A (55 to 61).

Regrowth of treated turf plugs (8 WAT) in sand culture in the greenhouse showed no harmful effects on root length, tiller production, rhizome number, or root dry weight.

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# MON 12000: A NEW HERBICIDE FOR NUTSEDGE CONTROL IN TURF

T. E. Dutt[1]

## ABSTRACT

MON 12000 is the code designation for Methyl 3-chloro-5-(4,6-dimethoxypyrimidin-2-ylcarbamoylsulfamoyl)-1-methylpyrazole-4-carboxylate. It is a new sulfonylurea herbicide under development by Monsanto Company for weed control in corn (Zea mays L.) and turfgrass.

Trials were conducted with MON 12000 during 1992 on a perennial ryegrass (Lolium perenne L.) golf course fairway in New Jersey for the control of yellow nutsedge (Cyperus esculentus L.), and during 1989 on a bermudagrass (Cynodon dactylon L.) golf course rough in Texas for the control of purple nutsedge (Cyperus rotundus L.). Test areas were heavily and uniformly infested with nutsedge. Each trial was a randomized complete-block design with 4 replications and 7 by 10 ft plots. Treatments were applied in water using flat-fan spray tips mounted on a compressed-air sprayer calibrated to deliver 25 and 50 gpa of spray solution. Postemergence applications were made to yellow nutsedge in the 6-9 leaf stage (up to 3 inches tall) and to purple nutsedge in the 6-12 leaf stage (up to 4 inches tall). Sequential applications were timed when significant regrowth of nutsedge occurred in select treatments. Nutsedge control and turfgrass safety evaluations were taken throughout the growing seasons (Tables 1 and 2).

The length of control provided by MON 12000 was rate-responsive on yellow nutsedge, but not on purple nutsedge. Significant regrowth of yellow nutsedge occurred by 5 weeks after treatment with 0.03 lb ai/A, and limited regrowth occurred by 6-8 weeks after treatment with 0.06 lb ai/A; however, the 0.12 lb ai/A treatment provided 90%+ control throughout the season. Significant regrowth of purple nutsedge occurred by 6-8 weeks after treatment with MON 12000 regardless of the rate applied. In these trials, sequential applications of MON 12000 provided season-long control similar to that achieved by sequential applications of bentazon on yellow nutsedge and imazaquin on purple nutsedge. However, MON 12000 provided greater turf safety to perennial ryegrass than bentazon and to bermudagrass than imazaquin.

MON 12000 shows excellent potential for use on both cool and warm season turfgrasses for the control of yellow and purple nutsedge. Results indicate that an application of 0.06 lb ai/A provides 6-8 weeks of control, and that repeat treatments of 0.03 lb ai/A may be necessary to provide season-long control.

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TABLE 1: Yellow nutsedge control in perennial ryegrass turf with MON 12000 and bentazon (Medford Lakes, NJ - 1992).

| Treatment[1] | Rate LB AI/A | Yellow Nutsedge 6/22 | 6/29 | 7/20 | 9/28 | Ryegrass[2] 6/22 | 8/3 | 8/31 |
|---|---|---|---|---|---|---|---|---|
| | | ----- % Control ------ | | | | % Injury | | %SR |
| MON 12000 | 0.03 | 48 | 86 | 45 | 34 | 0 | 0 | 5 |
| MON 12000 | 0.06 | 35 | 93 | 80 | 88 | 0 | 0 | 13 |
| MON 12000 | 0.12 | 58 | 93 | 94 | 96 | 0 | 0 | 20 |
| MON 12000 | 0.03 + 0.03 | 40 | 86 | 56 | 96 | 0 | 0 | 10 |
| MON 12000 | 0.06 + 0.06 | 50 | 91 | 75 | 100 | 0 | 0 | 13 |
| bentazon | 1.50 + 1.00 | 86 | 75 | 95 | 90 | 9 | 0 | 15 |
| Untreated | | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| LSD (.05) | | 19 | 7 | 18 | 19 | 6 | NS | NS |

[1]Initial Treatments applied June 8; sequential bentazon treatment applied 3 weeks later on June 29; and sequential MON 12000 treatments applied 6 weeks later on July 20. X-77 surfactant at 0.5% v/v added to MON 12000 treatments, and crop oil concentrate at 1% v/v added to bentazon treatments.

[2]%Injury = % foliar discoloration of ryegrass compared to untreated check; and %SR = % stand reduction.

TABLE 2: Purple nutsedge control in bermudagrass turf with MON 12000 and imazaquin (Ft. Worth, TX - 1989).

| Treatment[1] | Rate LB AI/A | Purple Nutsedge 7/3 | 8/21 | 9/4 | 10/16 | Bermudagrass[2] 7/3 | 8/28 | 9/4 |
|---|---|---|---|---|---|---|---|---|
| | | ----- % Control ----- | | | | %GR | %SHS | %Injury |
| MON 12000 | 0.03 + 0.03 | 90 | 25 | 98 | 31 | 3 | 0 | 0 |
| MON 12000 | 0.06 + 0.03 | 90 | 25 | 96 | 24 | 3 | 0 | 0 |
| MON 12000 | 0.06 + 0.06 | 94 | 25 | 98 | 32 | 3 | 0 | 0 |
| MON 12000 | 0.12 + 0.06 | 92 | 45 | 99 | 30 | 3 | 0 | 0 |
| imazaquin | 0.38 + 0.38 | 88 | 35 | 99 | 44 | 11 | 95 | 15 |
| imazaquin | 0.50 + 0.50 | 89 | 40 | 98 | 69 | 21 | 94 | 12 |
| LSD (.05) | | 5 | NS | NS | 32 | 5 | 5 | 6 |

[1]Initial treatments applied June 16 and sequential treatments applied 8 weeks later on August 21. X-77 surfactant at 0.5% v/v added to all treatments.

[2]Compared to an untreated check - %GR = % growth reduction; %SHS = % seedhead suppression; and %Injury = % foliar discoloration of bermudagrass.

# CONTROL OF ANNUAL BLUEGRASS IN CREEPING BENTGRASS TURF WITH MULTIPLE APPLICATIONS OF ETHOFUMESATE

D.R. Spak[1] and R.B. Taylorson[2]

A study was initiated in the fall of 1991 to evaluate the control of annual bluegrass (Poa annua L.) using multiple applications of ethofumesate (Prograss SC) in 'Penncross' creeping bentgrass (Agrostis palustris Huds.) turf. The study was conducted at a sod farm located in Kingston, RI. Creeping bentgrass was maintained at 0.25 inch and was established from seed three months prior to the first treatment application. The initial annual bluegrass population, averaged over the site, was 22%. Three applications were made at 21 day intervals, beginning September 18, with a $CO^2$-pressurized sprayer calibrated to deliver 44 gal/A. Rates evaluated were 0.5, 0.75, and 1.0 lb ethofumesate/A. The timing of the third application at 0.5 and 0.75 lb/A was compared; fall vs. spring (at green-up) application. Visual evaluations were made approximately 14 days after each application and included annual bluegrass control and turf injury (turf color and density). All treatments provided some level of annual bluegrass control (Table). Higher rates of ethofumesate were most efficacious, but turf injury was also greater. Delaying the third ethofumesate application of 0.5 or 0.75 lb/A until April did not change annual bluegrass control or turf injury. Substitution of oxadiazon (Ronstar 2G) for the spring application of ethofumesate appeared to be less effective, suggesting the importance of postemergence control of overwintering annual bluegrass plants. Turf density reductions induced by ethofumesate were caused by reducing the annual bluegrass population and by injuring the creeping bentgrass. Based on the initial annual bluegrass population in each plot, density reductions were primarily a result of annual bluegrass control; the exception was ethofumesate at 1.0 lb/A where half of the density decline was attributed to bentgrass injury.

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Table 1. Influence of ethofumesate rate and timing of application on annual bluegrass control and 'Penncross' creeping bentgrass color and density.

| Treatment | Rate | Timing | Annual bluegrass control † | | | | Turf color ‡ | | | | Turf density§ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | lb ai/A | | 24 Oct | 21 Nov | 1 Apr | 4 May | 24 Oct | 21 Nov | 1 Apr | 4 May | 4 May |
| Untreated | - | - | 0.0e¶ | 0.0c | 0.0d | 0.0d | 10.0a | 7.5ab | 10.0a | 10.0a | 10.0a |
| Ethofumesate | 0.50 | S,O,N | 2.0d | 2.3b | 6.9ab | 6.4bc | 8.4b | 8.6a | 9.2abc | 9.9a | 9.5a |
| Ethofumesate | 0.75 | S,O,N | 3.8bc | 5.3a | 8.8a | 8.4ab | 6.8c | 7.4ab | 8.4d | 9.6a | 7.4c |
| Ethofumesate | 1.00 | S,O,N | 5.3a | 7.0a | 9.5a | 9.5a | 5.5d | 5.6b | 7.2e | 9.5ab | 6.0d |
| Ethofumesate | 0.75/0.50 | S/O,N | 2.8cd | 1.8bc | 9.0a | 7.0b | 8.0b | 9.0a | 9.4ab | 9.8a | 9.1ab |
| Ethofumesate | 0.50 | S,O,A | 2.0d | 2.3b | 4.0c | 4.6c | 8.5b | 9.8a | 9.8a | 9.9a | 9.8a |
| Ethofumesate | 0.75 | S,O,A | 4.3ab | 6.0a | 8.4a | 9.5a | 6.5cd | 7.6ab | 9.0bcd | 9.1b | 7.9c |
| Ethofumesate | 0.75 | S,O | | | | | | | | | |
| Oxadiazon | 2.00 | A | 4.0abc | 5.8a | 7.6ab | 6.9bc | 6.2cd | 7.0ab | 8.6cd | 9.5ab | 8.2bc |

† Annual bluegrass control was rated on a scale of 1 to 10 with 10=complete control and 1=no control.
‡ Turf color was rated on a scale of 1 to 10 with 10=excellent color and 1=very poor color.
§ Turf density was rated on a scale of 1 to 10 with 10=100% turf cover and 1=no cover.
¶ Means within a column followed by the same letter are not significantly different, Duncan's Multiple Range Test (P=0.05).
S,O,N,A are September 18, October 9, November 5, and April 1 application dates, respectively.

# THE RESPONSE OF BENTGRASS AND POA ANNUA TO APPLICATIONS OF FLURPRIMIDOL

T. L. Watschke, K. Kallenbach, and J. Clark[1]

## ABSTRACT

Flurprimidol (Cutless) is labeled for application to mixed creeping bentgrass (Agrostis palustris) and annual bluegrass (Poa annua) swards as a means of shifting the plant population to predominately creeping bentgrass. Some research has documented population changes in favor of creeping bentgrass, however, there are also reported inconsistencies. Research is needed to document the individual species responses to flurprimidol so that the population dynamics of treated mixed swards can be better understood.

A greenhouse study was conducted to evaluate flurprimidol for its affect on the stolon growth of bentgrass and the basal tillering rate annual bluegrass. Individual tillers of 'Penncross' creeping bentgrass and native annual bluegrass were established in a Hagerstown silt loam soil in a greenhouse from January 23 to February 1, 1992. On February 21, stolon internodal lengths on the bentgrass and basal tillers of the annual bluegrass were measured on those plants selected for treatment with flurprimidol. On March 29, flurprimidol was applied at 0.5, 0.6, and 1.0 lb product/A to one half of each flat. Plant measurements were made on both species for 88 days following treatment.

Tiller counts of annual bluegrass treated with all flurprimidol rates were approximately the same as untreated plants for the first 51 days. Counts taken 88 DAT revealed that a trend had developed where by plants on the treated half of the 0.5 lb product/A flat had 2, the 0.6 lb product/A had 4, and the 1.0 lb product/A had 8 more tillers than plants on the untreated half of the flat. All flurprimidol rates caused a dwarfing response (caused by reduced leaf sheath growth). This response was still evident for the high rate after 88 days. Discoloration was also observed for all treatment rates; however, by 51 days there were no color differences between treated and untreated plants. The dwarfing/stunting response by the annual bluegrass, particularly at the high rate, restricted lateral spread even though treated plants produced more tillers than untreated plants (less space was used by more tillers). Creeping bentgrass plants had a slight and temporary discoloration at the high rate and had decreased vertical growth throughout the experiment. Internodal length measurements were variable and not consistent.

It appears that any competitive advantage afforded creeping bentgrass in a mixed sward treated with flurprimidol is associated with its ability to produce normal stolon growth, while annual bluegrass is less capable of occupying space even though the flurprimidol application has had a tendency to cause increased basal tillering.

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# EFFECT OF SPRAY ADJUVANTS ON THE ACTIVITY OF PLANT GROWTH REGULATORS APPLIED TO TALL FESCUE

Arthur E. Gover, Thomas L. Watschke, and David A. Batey[1/]

## ABSTRACT

As part of a cooperative project with the Pennsylvania Department of Transportation, studies were conducted in 1991 and 1992 to evaluate the effect of different spray adjuvants on the activity of plant growth regulator (PGR) treatments applied to tall fescue (Festuca arundinacea Schreb.). The adjuvant treatments included no additional spray adjuvant; X-77[2/], a synthetic, non-ionic spreader-sticker; CideKick II[3/], a *d*-limonene based, non-ionic spreader-sticker-penetrant; and Clean Cut[4/] and HyGrade Plus[5/], two petroleum based crop oil concentrates. The PGR treatments used in 1991 were mefluidide at 0.38 lb ai/ac, and mefluidide plus chlorsulfuron at 0.19 plus 0.012 lb ai/ac, respectively. The PGR treatments used in 1992 were mefluidide plus a commercial premix of imazethapyr and imazapyr[6/] at 0.12 plus 0.046 (0.044 plus 0.0016) lb ai/ac, respectively; and mefluidide plus chlorsulfuron at the same rates as in 1991. The study was conducted each year on a blend of 'Cimmaron', 'Bonanza', and 'Olympia' tall fescues, maintained at 3.5 in, at the Penn State Landscape Management Research Center, University Park, PA. The experimental design used both years was a randomized complete block with a split-plot treatment arrangement, with PGR as the whole plot treatment and spray adjuvant as the sub-plot treatment, with three replications. Application equipment for both studies was a $CO_2$-powered, hand-held boom equipped with Spraying Systems 8002 flat fan spray tips. Treatments were applied to 6 by 15 plots in 17 gal/ac at 30 psi on May 3, 1991; and to 3 by 15 ft plots in 16 gal/ac at 24 psi on May 1, 1992. In 1991, dicamba was tank-mixed with all treatments at 0.5 lb ai/ac, and in 1992, a premix of 2,4-D, MCPP, and dicamba was tank-mixed with all treatments at 1.0, 1.0, plus 0.5 lb ai/ac, respectively.

In 1991, a visual rating of turf color and quality was taken May 21, 18 days after treatment (DAT), using a scale of 1 to 9, where '1'=dead turf, '9'=ideal, and '5' is the lowest acceptable rating for low maintenance turf. Turf canopy height was measured June 5 (33 DAT) using a 12 in wide by 0.25 in thick wooden disk mounted on a 3 ft ruler, which was dropped from a height of 3 ft onto the turf, and the height the disk was suspended above the ground was recorded. Three height measurements were taken per plot. Fresh clipping weights were taken June 13 and July 16 (41 and 74 DAT), using a 20 in rotary mower with a cutting height of 3.5 in. Subsamples were taken at the 41 DAT harvest, and weighed fresh and dry to determine dry matter content and dry weight clipping yields. The plots were irrigated at 0.75 in/week between the two clippings harvests, to enhance recovery from the drought conditions present during the study. Data collected in 1992 included a visual rating of turf color and a measurement of vegetative canopy height on May 27 (26 DAT), and a fresh clipping harvest using a 20 in rotary mower with a cutting height of 3.0 in on June 18 (48 DAT). Seedhead suppression was excellent for all treatments both years.

There was no significant interaction between PGR treatment and spray adjuvant in either year. PGR treatment did not have a significant effect on any dependent variable in 1991. In 1992, there was a turf color difference, as all plots treated with mefluidide plus imazethapyr and imazapyr received a rating of '6', and all plots treated with mefluidide plus chlorsulfuron were rated a '5'. In 1991, spray adjuvant had a significant effect on turf color only, with Clean Cut receiving a lower rating than turf treated with no adjuvant or CideKick II (Table 1a). IThere was no significant effect on any dependent variable due to adjuvant treatment in 1992 (Table 1b).

Under the conditions of this study, which included drought conditions both years, the addition of spray adjuvants to PGR treatments applied to tall fescue did not influence the activity of the treatments, except for minor turf color differences observed in 1991 only, despite the range of penetrating abilities of the adjuvants.

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2/ Valent U.S.A. Corporation, Walnut Creek, CA.

3/ Brewer International, Vero Beach, FL.

4/ Arborchem Products, Ft. Washington, PA.

5/ CWC Chemical, Inc., Cloverdale, VA.

6/ [illegible]

TABLE 1a: Results from the addition of five adjuvants to two different plant growth regulator treatments applied to tall fescue on May 3, 1991. Turf color and quality were visually rated on May 21 (18 DAT), on a scale of 1 to 9, where '1' = dead turf, '9'= ideal, and '5' the lowest rating acceptable for roadside turf. Canopy height was measured June 5 (33 DAT) by suspending a disk 3 ft above the ground, dropping it, and measuring its distance from the ground. Fresh clipping weights were taken June 13 (41 DAT) with a rotary mower at 3.5 in. Subsamples were weighed fresh and dry to determine dry matter content and dry weight yield. Fresh clipping weights were taken July 16 (74 DAT) to determine regrowth from the previous mowing. Each value is the mean of six observations.

| Adjuvant | Turf Color 18 DAT | Turf Quality 18 DAT | Canopy Height 33 DAT | Fresh Weight 41 DAT | Dry Matter Content 41 DAT | Dry Weight 41 DAT | Fresh Weight 74 DAT |
|---|---|---|---|---|---|---|---|
| | (1-9) | (1-9) | (in) | (lb/M)1/ | ( % ) | (lb/M) | (lb/M) |
| none | 7.2 | 6.6 | 7.3 | 132 | 42.7 | 57 | 91 |
| X-77 | 7.0 | 6.3 | 7.6 | 133 | 42.7 | 56 | 76 |
| Clean Cut | 6.8 | 6.3 | 7.0 | 147 | 42.1 | 61 | 76 |
| HyGrade Plus | 7.0 | 6.5 | 7.2 | 149 | 44.2 | 63 | 87 |
| CideKick II | 7.2 | 6.4 | 6.8 | 129 | 42.0 | 55 | 79 |
| Probability Level (P) | 0.0095 | 0.1400 | 0.6609 | 0.9673 | 0.9757 | 0.9640 | 0.3627 |
| C.V. | 2 | 3 | 12 | 43 | 14 | 37 | 18 |
| LSD (P=0.05) | 0.3 | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |

TABLE 1b: Results from the addition of spray adjuvants to two different plant growth regulator treatments applied to tall fescue on May 1, 1992. On May 27 (26 DAT), vegetative canopy height was measured; and turf color was visually rated on a scale of 1 to 9, where '1'=dead turf, '9'=darkest green, and '5' is the lowest acceptable rating for roadside turf. Fresh clippings weights were taken with a rotary mower at 3.0 in on June 18 (48 DAT). Each value is the mean of 6 observations.

| Adjuvant | Vegetative Canopy Height 26 DAT | Turf Color 26 DAT | Fresh Weight 48 DAT |
|---|---|---|---|
| | (in) | (1-9) | (lb/M)1/ |
| none | 6.2 | 5.5 | 34.2 |
| X-77 | 6.2 | 5.5 | 30.0 |
| Clean Cut | 6.2 | 5.5 | 30.0 |
| HyGrade Plus | 6.0 | 5.5 | 28.1 |
| CideKick II | 6.3 | 5.5 | 34.2 |
| Probability Level (P) | 0.8686 | -- | 0.3926 |
| C.V. (%) | 6 | -- | 21 |
| LSD (P=0.05) | n.s. | -- | n.s. |

1/ Clipping yields are reported as lbs/1000 $ft^2$

# COMPARISON OF MEFLUIDIDE AND SETHOXYDIM AS PLANT GROWTH REGULATORS IN TALL FESCUE

Arthur E. Gover, David A. Batey, and Thomas L. Watschke[1/]

## ABSTRACT

A study evaluating sethoxydim as an alternative to mefluidide for use as a plant growth regulator was initiated May 11, 1992 at The Penn State Landscape Management Research Center in University Park, PA, as part of a cooperative project with the Pennsylvania Department of Transportation. The study was established on a six year old stand of 'Bonanza', 'Cimmaron', and 'Olympia' tall fescues ( Festuca arundinacea Schreb.). The study included nine treatments arranged in a randomized complete block design, with three replications. The treatments were applied to 3 by 15 ft plots with a $CO_2$ pressurized backpack sprayer delivering 15.8 gal/ac at 24 psi using Spraying Systems 8002 flat fan spray tips. The treatments were chlorsulfuron at 0.012 lb ai/ac plus either mefluidide at 0.188 lb ai/ac, or sethoxydim at 0.063, 0.093, or 0.125 lb ai/ac; a commercial premix of imazethapyr and imazapyr[2/] at 0.046 lb ai/ac ( 0.044 plus 0.0016 lb ai/ac, respectively) plus either mefluidide at 0.125 lb ai/ac, or sethoxydim at 0.063, 0.093, or 0.125 lb ai/ac; and an untreated check. A non-ionic spray adjuvant was included in all plant growth regulator treatments at 0.25 % v/v.[3/]

On June 2, 22 days after treatment (DAT), visual ratings of turf color were taken on a 1 to 9 scale where '1' = dead turf, '9' = darkest green, and '5' being the lowest acceptable rating for low maintenance turf; and vegetative canopy height measurements were taken at two locations in each plot. On June 17, 37 DAT, fresh clipping weights were taken with a 20 in rotary mower with a cutting height of 3 in. A subsample was taken from each plot, and weighed fresh and dry to determine dry matter content and dry weight clipping yields. Fresh plot weights were taken on July 24, 1992, 74 DAT, to determine recovery. Results are reported in Table 1.

The color rating for the untreated check was significantly better than all treated plots while the combination of mefluidide plus chlorsulfuron and mefluidide plus imazethapyr plus imazapyr were significantly better than all treatments which included sethoxydim. All turf color ratings for sethoxydim treated plots were unacceptable. Vegetative canopy height , and fresh and dry weight clipping yields taken 37 DAT were similar among all treated plots, while the untreated checks were significantly greater. No differences in dry matter content were found among any of the treatments. Plot regrowth 74 DAT in the untreated check was significantly lower than for the treated plots. All treatments provided excellent seedhead control.

Sethoxydim provided growth inhibition similar to mefluidide treatments, but under the conditions and rates used in this study, sethoxydim would not be an acceptable component of a plant growth regulator treatment due to unacceptable discoloration of tall fescue. Lower rates of sethoxydim may reduce the discoloration resulting from the treatment and still provide acceptable results, as the lowest rates used in this study provided excellent inhibition of seedheads and foliage growth.

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[2/]Event, containing 1.43 lb/gal imazethapyr and 0.03 lb/gal imazapyr, American Cyanamid Co., Wayne, NJ.

[3/]Cidekick II, Brewer International, Vero Beach, FL.

TABLE 1: Results for plant growth regulator treatments applied May 11, 1992, to tall fescue. Vegetative canopy measurements and visual color ratings were taken on June 2, 22 days aftter treatment (DAT). Fresh clipping weights were taken on June 17, 37 DAT, and included detemination of dry matter content and dry weight yields. Fresh clipping weights were also taken July 24, 74 DAT. Each value is the mean of three replications.

| Treatment | Application Rate | Turf Color 22 DAT | Vegetative Canopy Height 22 DAT | Fresh Weight 37 DAT | Dry Weight 37 DAT | Dry Matter Content 37 DAT | Fresh Weight 74 DAT |
|---|---|---|---|---|---|---|---|
| | ( lb ai/ac ) | ( 1-9 ) | ( in ) | ( lb/1000 $ft^2$ ) | ( lb/1000 $ft^2$ ) | ( % ) | ( lb/1000 $ft^2$ ) |
| 1. mefluidide + chlorsulfuron | 0.19<br>0.012 | 6.0 | 6.3 | 37 | 12 | 34.3 | 19 |
| 2. sethoxydim + chlorsulfuron | 0.063<br>0.012 | 4.7 | 5.8 | 38 | 14 | 35.9 | 17 |
| 3. sethoxydim + chlorsulfuron | 0.093<br>0.012 | 4.3 | 6.6 | 40 | 13 | 33.3 | 21 |
| 4. sethoxydim + chlorsulfuron | 0.125<br>0.012 | 4.0 | 6.3 | 38 | 14 | 37.5 | 18 |
| 5. mefluidide + imazethapyr+imazapyr[1/] | 0.12<br>0.044 + 0.0016 | 6.7 | 6.3 | 46 | 16 | 34.2 | 19 |
| 6. sethoxydim + imazethapyr+imazapyr | 0.063<br>0.044 + 0.0016 | 4.3 | 6.0 | 36 | 13 | 36.1 | 17 |
| 7. sethoxydim + imazethapyr+imazapyr | 0.093<br>0.044 + 0.0016 | 4.0 | 6.3 | 47 | 18 | 36.8 | 22 |
| 8. sethoxydim + imazethapyr+imazapyr | 0.12<br>0.044 + 0.0016 | 3.7 | 6.3 | 42 | 15 | 35.8 | 22 |
| 9. untreated check | - - - | 9.0 | 8.3 | 95 | 34.5 | 38.2 | 10 |
| Significance Level (P) | | 0.0001 | 0.0003 | 0.0018 | 0.0001 | 0.9470 | 0.0056 |
| C.V. (%) | | 8 | 7 | 29 | 25 | 14 | 17 |
| LSD (P=0.05) | | 0.8 | 0.8 | 24 | 7 | n.s. | 5 |

[1/]Event, containing 1.43 lb/gal imazethapyr and 0.03 lb/gal imazapyr, American Cyanamid Co., Wayne, NJ.

# EVALUATION OF TRINEXAPAC-ETHYL IN COMBINATION WITH SEVERAL PLANT GROWTH REGULATORS APPLIED TO TALL FESCUE

Arthur E. Gover, Thomas L. Watschke, and David A. Batey[1/]

## ABSTRACT

As part of a cooperative research project with the Pennsylvania Department of Transportation, a study evaluating the growth regulation of tall fescue (Festuca arundinacea Schreb.) with trinexapac-ethyl in combination with other plant growth regulators was established May 1, 1992, at the Landscape Management Research Center of the Pennsylvania State University. Trinexapac-ethyl at rates of 0, 0.125, and 0.25 lb ai/ac was applied alone and in combination with mefluidide at 0.125 lb ai/ac; a commercial premix of imazethapyr and imazapyr[2/] at 0.044 plus 0.0016 lb ai/ac, respectively; chlorsulfuron at 0.012 lb ai/ac; and metsulfuron methyl at 0.0094 lb ai/ac. These treatments were applied to a six year old stand of a blend of 'Cimmaron', 'Bonanza', and 'Olympia' turf-type tall fescues. The applications were made to 3 by 15 ft plots in a randomized complete block design with a factorial treatment arrangement and three replications, using a $CO_2$ powered, hand-held sprayer delivering 15.8 gal/ac at 20 psi using Spraying Systems 8002 flat fan spray tips. All plots except the untreated check were also treated with a commercial premix of 2,4-D, MCPP, and dicamba, at 1.0, 1.0, and 0.25 lb ae/ac, respectively, tank mixed with the growth regulator treatments.

Vegetative canopy height was estimated at two locations in each plot on May 29, 28 days after treatment (DAT). Seedhead height and density were measured June 12, 42 DAT. Seedhead density was measured by counting the number of seedheads in a single 0.25 $m^2$ quadrat placed in each plot. Clipping yields were taken June 18 and July 27, 47 and 87 DAT, respectively, using a 20 in rotary mower set at 3 in. A clippings subsample was taken from each plot at the 47 DAT harvest, and weighed fresh and dry to determine dry matter content and dry weight clipping yield. The data were subjected to analysis of variance, and means separations performed using Fisher's Protected lsd test.

There was no significant interaction between trinexapac-ethyl rate and plant growth regulator treatment for any dependent variable. Trinexapac-ethyl rate had a significant effect on vegetative canopy height, seedhead height, and dry weight yields (Table 1a). There was a significant decrease in vegetative canopy height and seedhead height with each increase in trinexapac-ethyl application rate. Dry weight clipping yields of turf treated with 0.25 lb ai/ac of trinexapac-ethyl were significantly lower than when treated with 0, or 0.125 lb ai/ac trinexapac-ethyl.

Plant growth regulator treatment had a significant effect on all dependent variables (Table 1b). Treatments including a growth regulator in addition to trinexapac-ethyl provided a reduction in vegetative canopy height, seedhead height, seedhead density, and clipping yields and dry matter content 47 DAT; and a significant increase in clipping yields 87 DAT, compared to treatments with no additional growth regulator. There were no turf color differences observed during the course of the study.

The addition of trinexapac-ethyl at increasing rates did increase the inhibition of turf growth without causing phytotoxicity, but the application rates used in this study were not sufficient to provide the degree of inhibition, particularly of seedhead production, that would be considered satisfactory. Future investigations of combination treatments should include increased application rates of the treatment components.

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[1/] Project Associate, Professor of Turfgrass Science, and Research Aide, respectively, The Pennsylvania State University, University Park, PA.

[2/] Event, containing 1.43 lb/gallon imazethapyr and 0.03 lb/gallon imazapyr, American Cyanamid Company, Wayne, NJ.

TABLE 1a: Results from three rates of trinexapac-ethyl applied to tall fescue on May 1, 1992, and averaged over five plant growth regulator treatments . Vegetative height was measured May 29 (28 DAT). Seedhead height and density were measured June 11 (42 DAT). Clipping weights were taken June 17 (47 DAT) at a height of 3 in using a rotary mower, and subsamples were taken to determine dry matter content and dry weight. Fresh clipping weights were taken July 27 (87 DAT) to determine post-mow regrowth. Each value is the mean of 15 observations.

| Treatment | Application Rate | Vegetative Height 28 DAT | Seedhead Height 42 DAT | Seedhead Density 42 DAT | Fresh Weight 47 DAT | Dry Matter Content 47 DAT | Dry Weight 47 DAT | Fresh Weight 87 DAT |
|---|---|---|---|---|---|---|---|---|
| | (lb ai/ac) | (in) | (in) | (seedhead/ft$^2$) | (lb/1000 ft$^2$) | (%) | (lb/1000 ft$^2$) | (lb/1000 ft$^2$) |
| none | - - - | 7.9 | 29.8 | 36 | 165 | 33.4 | 55 | 37 |
| trinexapac-ethyl | 0.125 | 7.5 | 28.7 | 40 | 163 | 33.6 | 55 | 38 |
| trinexapac-ethyl | 0.25 | 7.1 | 26.7 | 40 | 149 | 32.4 | 48 | 38 |
| Probability Level (P) | | 0.0002 | 0.0001 | 0.2986 | 0.1217 | 0.1397 | 0.0368 | 0.8366 |
| C.V. (%) | | 6 | 5 | 23 | 14 | 5 | 14 | 11 |
| LSD (P=0.05) | | 0.4 | 1.1 | n.s. | n.s. | n.s. | 5 | n.s. |

TABLE 1b: Results from five plant growth regulator treatments applied to tall fescue on May 1, 1992, averaged over three rates of trinexapac-ethyl. Vegetative height was measured May 29 (28 DAT). Seedhead height and density were measured June 11 (42 DAT). Clipping weights were taken June 17 (47 DAT) at a height of 3 in using a rotary mower, and subsamples were taken to determine dry matter content and dry weight. Fresh clipping weights were taken July 27 (87 DAT) to determine post-mow regrowth. Each value is the mean of 9 observations.

| Treatment | Application Rate | Vegetative Height 28 DAT | Seedhead Height 42 DAT | Seedhead Density 42 DAT | Fresh Weight 47 DAT | Dry Matter Content 47 DAT | Dry Weight 47 DAT | Fresh Weight 87 DAT |
|---|---|---|---|---|---|---|---|---|
| | (lb ai/ac) | (in) | (in) | (seedhead/ft$^2$) | (lb/1000 ft$^2$) | (%) | (lb/1000 ft$^2$) | (lb/1000 ft$^2$) |
| none | - - - | 8.8 | 31.6 | 19 | 176 | 34.7 | 60 | 31 |
| mefluidide | 0.12 | 8.0 | 29.6 | 13 | 165 | 32.9 | 54 | 35 |
| imazethapyr + imazapyr[1/] | 0.046 | 6.9 | 24.0 | 10 | 157 | 32.2 | 51 | 39 |
| chlorsulfuron | 0.012 | 6.6 | 27.3 | 14 | 145 | 32.6 | 47 | 41 |
| metsulfuron methyl | 0.0094 | 7.0 | 29.7 | 16 | 151 | 33.2 | 50 | 42 |
| Probability Level (P) | | 0.0001 | 0.0001 | 0.0001 | 0.0399 | 0.0345 | 0.0085 | 0.0001 |
| C.V. (%) | | 6 | 5 | 23 | 14 | 5 | 14 | 11 |
| LSD (P=0.05) | | 0.5 | 1.5 | 3 | 21 | 1.6 | 7 | 4 |

[1/] Event, containing 1.43 lb/gal imazethapyr and 0.03 lb/gal imazapyr, American Cyanamid Company, Wayne, NJ.

# An Overview of Trinexapac-ethyl Trials - 1992

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## ABSTRACT

Trinexapac-ethyl (CGA-163935) is a plant growth regulator developed by CIBA-GEIGY Corporation for management of high maintenance cool- and warm-season turfgrasses. Trinexapac-ethyl was tested successfully under an Experimental Use Permit (EUP) program in 1991 and 1992. The EUP program was conducted on golf courses, sod farms, and commercial and residential home lawns. Rates of trinexapac-ethyl ranged from 50 to 900 g ai/ha (0.13 to 2.4 fl. oz./1,000 sq. ft. product).

In the northeastern United States, EUP trials were conducted in New York, Connecticut, Rhode Island, Pennsylvania, Maryland, Ohio, and Michigan. Cool-season turf species treated in these trials included bentgrass (*Agrostis palustris* Huds.), Kentucky bluegrass (*Poa pratensis* L.), tall fescue (*Festuca arundinacea* Schreb.), and perennial ryegrass (*Lolium perenne* L.). Parameters measured in 1992 included mowing reductions, clipping volumes, turf color and quality, effects on overseeding, and tank-mix compatibilities.

The EUP program confirmed the effectiveness of trinexapac-ethyl in reducing grass clippings and frequency of mowings on a wide range of turf species. Duration of activity was influenced by rate, environmental conditions, and turf species. A darker green turf color was evident at many locations two to six weeks after application. Bentgrass overseeded one day after treatment germinated normally after an application of trinexapac-ethyl at 150 to 900 g ai/ha. No interactions were noted when trinexapac-ethyl was applied to bentgrass treated six weeks earlier with either mefluidide or paclobutrazol. No incompatibilities were observed with a wide range of tank-mix partners. No detrimental effects were observed in Kentucky bluegrass treated with trinexapac-ethyl at 250 g ai/ha three times per year in a trial conducted over three years.

[1/] CIBA-GEIGY Corp., 1200 Washington Rd., Washington, PA 15301

# TERBUFOS INTERACTION WITH THREE HERBICIDES AND EFFICACY OF BATTALION AND PERMIT ON TWO SWEET CORN VARIETIES

Ed Kee and Tracy Wootten[1]

## ABSTRACT

Two separate studies were initiated in 1992 on sweet corn. In the first study, two varieties of sweet corn, Jubilee and Silver Queen were planted. Terbufos, a granular insecticide, was applied in furrow at 8 ounces/1000 linear feet of row. The corn was sprayed pre-emergence with treatments of metolachlor, metolachlor and cyanazine, alachlor, and alachlor and cyanazine. Stand counts and vigor ratings taken periodically after application revealed no difference in corn growth, vigor, or stand.

The second study was an evaluation of the efficacy and phytotoxicity of Battalion and Permit on the sweet corn varieties Jubilee and Silverado. There were no varietial responses. Post-emergence applications of Permit stunted corn growth, but did partially control grasses. Pre-emergence applications of Battalion provided significantly less control of grasses that treatments of alachlor.

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# PHYTOTOXICITY AND EFFICACY OF SAN 582, ALACHLOR AND METOLACHLOR IN SEVERAL VEGETABLE CROPS

**Bradley A. Majek and Jack Rabin[1]**

## ABSTRACT

A wide variety of vegetable crops were evaluated for tolerance to SAN 582H applied preemergence at 1.5 lb ai/A and compared with metolachlor at 2.0 lb ai/A. In the early cool-season vegetable screen, spinach and cabbage were only slightly affected by metolachlor. Both crops were less tolerant to SAN 582H. Parsley, lettuce, and onions were severely injured by both herbicides. A variety of crops in the warm season screen, including tomatoes, peppers, pumpkins, snap beans, and sweet corn, were not significantly injured by either herbicide. Cucumbers and parsley were injured.

Potatoes, tomatoes, and sweet corn tolerance to SAN 582 were also evaluated for its effect on yield and earliness or quality. Twenty-three sweet corn varieties were screened to determine if varietal differences exist to the crops tolerance to SAN 582H. Potatoes were moderately to severely injured by SAN 582H applied at 0.75 to 3.0 lb ai/A after drag-off. Tomato tolerance to SAN 582H preplant incorporated at 1.0 to 2.0 lb ai/A was good. Sweet corn tolerance to SAN 582H was acceptable. Slight temporary stunting, which was statistically not significant, was observed on several varieties treated with 1.5 lb ai/A preemergence. Injury to the variety, 'Champ,' was significant. No sweet corn variety was injured by alachlor applied at 3.0 lb ai/A preemergence.

The weed control obtained with SAN 582H was generally effective at half the rate of alachlor or metolachlor. When compared at half the rate with alachlor or metolachlor, the control of barnyardgrass, giant foxtail, smooth pigweed, and hairy galinsoga were not significantly different. Common lambsquarter control with any of the three herbicides was unacceptable, but common lambsquarter was more effectively suppressed with alachlor, when compared to an equivalent rate of metolachlor or half the rate of SAN 582H. Doubling the rate of SAN 582H resulted in common lambsquarter suppression that was significantly better than the results with alachlor.

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# Crop Injury and Weed Control with DPX-E9636 in Potatoes.

**Russell W. Wallace and Robin R. Bellinder[1]**

The new, short residual, sulfonylurea herbicide, DPX-E9636, was evaluated for crop tolerance and weed control in four potato (Solanum tuberosum L.) varieties (Atlantic, Katahdin, Monona, and Superior). Treatments included a chemical standard, metolachlor (1.5 lb ai/A) + linuron (1.5 lb ai), applied delayed preemergence; DPX-E9636 alone (0.031, 0.062 lb ai); and DPX-E9636 (0.031 lb ai) + metribuzin (0.19 lb ai). All DPX-E9636 treatments were applied postemergence, 5 weeks after planting. Weed species evaluated were: redroot pigweed (Amaranthus retroflexus L.), common lambsquarters (Chenopodium album L.), hairy galinsoga (Galinsoga ciliata Raf. Blake), and common chickweed (Stellaria media L. Vill.). DPX-E9636 caused 5 to 10% apical chlorosis 3 days after treatment (DAT) in all four varieties. By 7 DAT, injury increased from 10 to 33% with Superior being the most sensitive variety. By 21 DAT, no injury symptoms were visible on any potato variety. Tank-mixing metribuzin with DPX-E9636 did not increase injury, except in the variety Superior. Two weeks after herbicide application all treatments controlled 96% of all weeds evaluated. Despite early injury, DPX-E9636 did not negatively affect yields of the four potato varieties.

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# VARIETY SENSITIVITY OF POTATOES TO E9636 AND METRIBUZIN

Ed Kee, Lisa Miller and Tracy Wootten[1]

## ABSTRACT

Various rates of E9636 and metribuzin, both alone and in combinations, were applied post-emergence to two varieties of potatoes, Belrus and Superior. No phytotoxic effects were experienced and weed control was generally good to excellent. E9636 was applied at rates ranging from 0.5 oz. active ingredient/acre to 1.0 ounce. Metribuzin rates ranged from 4 to 8 ounces active ingredient/acre.

E9636 was applied post-emergence to 25 varieties of potatoes at 1 ounce active ingredient/acre. No significant phytotoxicity was experienced and weed control was excellent. Potato varieties tested were from the Round White, Russet, and Red classes.

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# DETERMINATION OF THE CRITICAL WEED FREE PERIOD FOR GROUND TOMATOES

Robert J. Durgy and Richard A. Ashley[1]

## ABSTRACT

Tomatoes (*Lycopersicon esculentum* L.) cv 'Heinz 1350' were grown on a Woodbridge fine sandy loam, 3 to 8 % slope on the Plant Science Research Farm at the University of Connecticut, Storrs, CT. Plants were started in the greenhouse and transplanted into the field on May 30, 1991. Plots were maintained weed free or left to compete with weeds for two to sixteen weeks. Tomatoes were harvested from August 27 to October 4. Number and weight of marketable fruit were recorded. Significant differences occurred between weed control treatment. The critical weed-free period was determined to be between two and six weeks after transplanting.

## INTRODUCTION

Weeds compete with field crops for light, water, nutrients and root space. At a point during the growth of crops, weed competition will cause significant reduction of yield(2). The purpose of this work is to determine that point for ground tomatoes. Critical weed free period is based on two separate components: (a) the length of time a crop must be free of weeds after planting so that later emerging weeds do not reduce yield, and (b) the length of time weeds which emerge with the crop can remain before they begin to interfere with crop growth(4).

The practicality of determining critical period seems insignificant due to differences that occur in cultural techniques, yearly weather conditions and varietal hardiness(2). It is a widely excepted practice to use plastic mulch for tomatoes which makes knowledge of the critical period rather useless. Application and disposal of this material has become a costly environmental problem. Critical period is not needed when herbicides will prevent

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weeds all season. But in states such as Connecticut, groundwater contamination has become a major concern. With knowledge of the critical period for tomatoes perhaps other weed management methods could be implemented.

## MATERIALS AND METHODS

The experiment was conducted in 1991 on the University of Connecticut Plant Science Research Farm in Storrs. The soil is a Woodbridge fine sandy loam with a 3 to 5 percent slope. The pH was 6.3. Fertilizer (15-15-15) was applied at 750 kg per hectare.

The plots consisted of three rows 3.1meters(m) long with 1.5m between rows and 0.4m between plants. Tomatoes (*Lycopersicon esculentum* L.) cv 'Heinz 1350' were started in the greenhouse and were transplanted in to the field May 30, 1991.

Treatments were arranged in a randomized complete block design with three replications. The weed free periods were broken into two week intervals using sixteen treatments. Treatments are described in Table 1.

Weeds were removed by mechanical cultivation, hoeing and hand pulling. The predominant weeds present were large crabgrass (*Digitaria sanguinalis* L.), common lambsquarters (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus* L.).

Deer damage occurred on about 75 percent of the plants before a fence was installed. Insect infestation was light enough to control by hand picking. Fungicide was applied as recommended by the New England Vegetable Management Guide starting July 17.

Tomatoes were harvested four times from August 27 to October 4. Numbers and weights of marketable fruit were recorded. Data was taken from the center row of each plot using eight plants in the row.

## RESULTS AND DISCUSSION

The yield from treatments that were weed free from weeks two to six were significantly greater than all other treatments (Table 1). There was no significant difference in yield between these treatments. A drastic difference occurred between treatments nine and ten. Treatment nine had double the yield that treatment ten had. This shows how weed competition during weeks three and four severely reduce yield. The difference between treatments six, weeded for the first six weeks, and treatment seven, which was weeded for the first four weeks was not so striking. Yield was

reduced only 15 percent which may mean that weeds emerging at transplant have a greater interference effect than those emerging after transplants have had time to establish. The results from this experiment correspond with results of other researchers which state the critical weed free period for tomatoes is the first seven weeks. (3,6)

## CONCLUSION

There was no significant difference between the week free control and those treatments that were weed free for the first six weeks which suggests that the critical period is during the first six weeks. Interference by redroot pigweed in potatoes (5) and by lambsquarters in broccoli (1) has shown similar effects.

TABLE 1. EFFECT OF WEED FREE PERIOD ON YIELD OF TOMATOES

| Treatments | # of fruit | kg of fruit |
|---|---|---|
| 1. weed free weeks 1 to 16 | 227.00 | 74.73 |
| 2. weed free weeks 1 to 14 | 216.67 | 76.38 |
| 3. weed free weeks 1 to 12 | 217.70 | 73.43 |
| 4. weed free weeks 1 to 10 | 241.67 | 80.50 |
| 5. weed free weeks 1 to 8 | 229.33 | 77.80 |
| 6. weed free weeks 1 to 6 | 212.00 | 74.13 |
| 7. weed free weeks 1 to 4 | 213.00 | 63.80 |
| 8. weed free weeks 1 to 2 | 111.33 | 33.90 |
| 9. weed free weeks 2 to 16 | 245.33 | 80.23 |
| 10. weed free weeks 4 to 16 | 140.00 | 42.93 |
| 11. weed free weeks 6 to 16 | 32.00 | 9.40 |
| 12. weed free weeks 8 to 16 | 20.00 | 4.50 |
| 13. weed free weeks 10 to 16 | 14.33 | 3.57 |
| 14. weed free weeks 12 to 16 | 16.67 | 3.50 |
| 15. weed free weeks 14 to 16 | 11.67 | 2.40 |
| 16. remained weedy | 8.67 | 1.73 |
| LSD 5% | 43.73 | 14.45 |

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# SHIELDED APPLICATION OF LACTOFEN FOR TOMATOES ON PLASTIC MULCH

C.Edward Beste[1], J.Ray Frank[2], Janice P. Donohoe[1], and Debra A. Dinkel[1]

## ABSTRACT

Studies were conducted in 1991 and 1992 with shielded directed spray applications of lactofen to the soil between strips of black plastic mulch with transplanted tomatoes (Lycopersicon esculentum Mill.) in a Norfolk loamy sand soil with 0.7% organic matter. In 1991, a separate experiment was conducted without black plastic mulch.

Lactofen at 0.56 kg/ha provided >95% weed control in 1991 as a pre-transplant application followed by two applications postemergence (total 1.7 kg/ha) between plastic mulch strips. This treatment did not reduce early 'Pik Red' tomato yield, however, late season yield was reduced 60%. Without plastic mulch strips, lactofen caused a reduction of early and total yield of 40% and 70%, respectively for 'Pik Red' tomatoes, as a broadcast preplant application followed by two shielded applications postemergence at 0.56 kg/ha (1.7 kg/ha total).

In 1992, lactofen at 1.4 kg/ha (4.2 kg/ha total), applied as a pre-transplant application followed by two postemergence shielded sprays between black plastic mulch strips, caused a 75% reduction of 'Sunny' tomato growth and reduced early and total yields 100% and 50%, respectively.

Tomato injury in 1991 appeared to be prevented by cultivation the day after lactofen pre-transplant application with black plastic mulch, whereas in 1992, cultivation was omitted. Cultivation did not prevent tomato injury from lactofen without plastic mulch in 1991, however, lactofen applications were applied directly under the tomato plants. Plastic mulch appeared to reduce the potential for lactofen injury to tomato.

Lactofen at 0.56 kg/ha provided >95% control of large crabgrass (Digitaria sanguinalis (L.) Scop.), goosegrass (Eleusine indica (L.) Gaertn.), fall panicum (Panicum dichotomiflorum Michx.), carpetweed (Mollugo verticillata L.), and ivyleaf morningglory (Ipomoea hederacea (L.) Jacq.), however, late season yields were reduced. Lactofen should be evaluated at rates less than 0.56 kg/ha for weed control between plastic strips for tomatoes.

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# Management Techniques for Tomatoes in Living Mulch

Robert J. Durgy and Richard Ashley[1]

ABSTRACT

Red clover (Trifolium pretence L.) living mulch has shown great promise for weed control. Several different management techniques were used to control competition between tomato (Cycopersicon esculentum L.) and the mulch while maintaining the weed control advantages A split plot design was used to test these techniques. The main plots were conventional tillage, living mulch and living mulch with one-foot tilled strips. The sub plots were banded metribuzin plus sethoxydim, broadcast metribuzin plus sethoxydim, infrared transmitting (IPT) plastic mulch, hand weeding through the critical period, hand weeding the entire crop season and no weed control. Rates of metribuzin and sethyoxydim were 0.6 kilogram active ingredient per hectare (kg a.i./had) and 0.32 kg a.i./ha respectively.

Weed ratings were taken 8 weeks after transplanting. Both mulch plots were significantly higher than the conventionally tilled plot. There was no significant difference between the two mulch plots. In untreated sub plots the untilled mulch offered 65 percent weed control versus conventional till. The tilled mulch had 40 percent control over conventional till. The dominant weed species present were common ragweed (Ambrosia artemisiifolia L.), ladysthumb (Polygonum persicaria L.) and Kentucky bluegrass (Poa pratensis L.). The perennial out competed the clover in several of the untreated and hand weeded sub plots. Yields were taken between September 8 and September 28. The conventionally tilled treatment yielded significantly more than either mulch treatment. The strip-tilled mulch plot yielded significantly more than the untilled mulch. A mean separation of the interaction between sub plots and main plots shows that no living mulch plot yielded as high as the broadcast application of herbicide on conventional till. There was no yield difference between IRT mulch on living mulch and IRT on conventional till, which was the second highest yielding.

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# *What's New in Table Beet Herbicides*

**Gregory R. Comeau and Robin R. Bellinder[1]**

Field studies were conducted at the H.C. Thompson Vegetable Research Farm, in Freeville NY to evaluate potential new herbicides for table beets (*Beta vulgaris)*. Sulfonylurea herbicides were evaluated in four table beets varieties: Detroit Dark Red, Red Ace, Ruby Queen (peto Seeds), and Ruby Queen (A. Christianson). In other studies, commonly used sugar beet herbicides, clopyralid, ethofumesate, EPTC, desmedipham, desmedipham + phenmedipham (Betamix®) were tested for crop tolerance and weed control. The sulfonylurea herbicide, DPX 66037 (0.016, 0.031 lbs ai/A.), was applied at 2-4 and 6-8 true leaves. Initial control of hairy galinsoga (*Galinsoga cilitia*) and Powell amaranthus (*Amaranthus powelli* S. Wats) was excellent (99%), however control of common lambsquarters (*Chenopodium album* L.) was less than 60%. To prevent weed competition the entire test was handweeded 10 days after the 2-4 leaf application in order to evaluate the effects of injury on yield. Detroit Dark Red was most sensitive to DPX 66037. Early injury led to a significant decrease in yield at 0.031 lbs ai. In the sugar beet herbicide trial, preplant-incorporated (PPI) ethofumesate, EPTC, pyrazon, cycloate, metalachlor, and diethatyl-ethyl controlled broadleaf weeds for 40 days after treatment. Later emerging weeds competed with the crop, significantly reducing yields. Multiple applications of Betamix® at 0.25 lbs ai (2-4 true leaves) + 0.38 lbs ai (6-8 true leaves) provided excellent broadleaf weed control and resulted in significantly higher yields than yields of beets treated with PPI herbicides. Additions of ethofumesate (1.7 lbs ai.) and clopyralid (0.19 lbs ai.) to Betamix® increases injury and decreases yield while not adding to weed control, in conditions where grass pressure was slight. Desmedipham (0.25 lbs ai.) alone provided excellent broadleaf weed control.

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## *Bentazon and Cucumbers: A Post-Emergence Weed Control Option*

**E.D. Wilkins and R.R. Bellinder[1]**

Greenhouse and field studies were conducted to measure cucumber (*Cucumis sativus)* growth and yield as affected by early season bentazon applications. In greenhouse studies, bentazon (0.5 and 1.0 lb ai/A), with and without crop oil concentrate (COC), was applied to 3 cucumber varieties (Poinsett 76, Dasher II, Meteor) at the 2- or 4-leaf stage. In these studies, stunting was significantly greater in 2-leaf stage plants at all bentazon rates when combined with COC. Early necrosis was 45% or greater when COC was used. Crop tolerance did not differ with variety. In the field, bentazon was applied at 0.25, 0.50, 0.75, and 1.0 lb ai/A, with and without COC, to cucumbers (var. Dasher II) having 1.5- or 3-true leaves. Necrosis and stunting were greatest in young plants at all rates greater than 0.25 lb ai/A both with and without COC, and in older plants with bentazon rates greater than 0.5 lb ai/A when combined with COC. Injury decreased rapidly and by the first harvest, stunting ranging from 0 to 16% was recorded but was highly variable. The treatments did not differ significantly. Despite early injury, ranging from 0 to 55% for necrosis and stunting, neither first nor total yields were reduced by any of the treatments. Control of hairy galinsoga (*Galinsoga ciliata*) and common lambsquarters (*Chenopodium album)* was greater than 90%, and control of redroot pigweed *(Amaranthus retroflexus*) was 80% when bentazon was applied at 0.75 and 1.0 lb ai/A, both with and without COC.

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# EFFECTS OF NAA SEED TREATMENT ON CUCUMBER TRANSPLANT GROWTH AND SENSITIVITY TO CLOMAZONE

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## ABSTRACT

Clomazone has been extensively tested for weed control in cucurbit crops in New Jersey. It has been labelled in pumpkins for several years and was labelled under Section 18 Exemptions in winter and summer squash for two years. Clomazone has caused unacceptable crop injury to both winter and summer squash when used at the labelled rate for pumpkins. Clomazone is presently recommended at .25 lb/A to .5 lb/A as a preplant incorporated application. Incorporation should be thorough, uniform, and shallow to prevent unacceptable crop injury. Napthalic anhydride (NAA) as a seed treatment has had some success in safening soil applications of clomazone in sweet corn. It was hypothesized that NAA could potentially safen soil applications of clomazone in cucurbit crops. Therefore, NAA and activated charcoal, which has also shown some success in safening herbicides in vegetables, were evaluated for potential safening of clomazone in cucumbers.

Preliminary greenhouse and field evaluations indicated that both NAA, used as a seed treatment, and activated charcoal, used in plugmix and transplant media, had some success in safening soil applications of clomazone but not at acceptable levels. However, cucumbers had significantly reduced plant height, at the time of transplanting, as a result of the NAA seed treatment. Since early plantings of transplanted cucumbers and other cucurbits are susceptible to poor growing conditions, especially to cold winds, seed treatments of NAA were evaluated for their effect on transplant production and subsequent transplant survival and yield of cucumber.

NAA applied at seeding, as a dust at the rate of .25%, .5%, 1.0%, and 2.0% (wt/wt), resulted in a height reduction in transplants. Cold windy weather the week after transplanting resulted in a stand loss of 70% for untreated seed. The use of NAA as a seed treatment significantly reduced stand loss and increased yield of cucumber.

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# POSTEMERGENCE WEED CONTROL WITH PYRIDATE IN CABBAGE, ONIONS, AND TOMATOES

S. F. GORSKI[1]

## ABSTRACT

Weed control and crop phytotoxicity studies were conducted at The Ohio State University research farms in Fremont, Celeryville, and Columbus. Replicated studies were conducted from 1987 thru 1992.

Small seeded broadleaf weeds such as common purslane (Portulaca oleracea L.), redroot pigweed (Amaranthus retroflexus), and black nightshade (Solanum nigrum) were easily controlled when treated at the 0 to 2 inch stage. Control of these weeds diminished as their size increased beyond the 2 inch stage. Black nightshade appears to be particularly sensitive to pyridate with acceptable control being obtained at the 4 to 5 inch stage of growth. Grass control was poor and unacceptable at most application rates and grass species tested. Tank mixes with postemergence grass herbicides increased grass control to almost 100%.

Cabbage tolerance to pyridate is good with multiple applications of 0.9 lbs. a.i./A. Tolerance begins at an early age for field seeded cabbage with little or no injury being observed when applications were made as early as the 2 to 4 true leaf stage. Injury is rarely seen with transplanted cabbage.

Field seeded onions exhibited a similar degree of tolerance to pyridate as did field seeded cabbage. Multiple applications of 0.9 lbs. a.i./A to onions beyond the 2 to 3 true leaf stage caused little or no crop injury.

Tomatoes are more sensitive to applications of pyridate. A single application at 0.9 lbs. a.i./A can cause severe injury. An application rate of 0.45 lbs. a.i./A causes little or no tomato injury. This rate of pyridate still provides acceptable control of black nightshade and many other smaller seeded broadleaf weeds. However, timing of the application becomes more important.

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# The Effect of Shielded Oxyfluorfen Applications in Direct-seeded Crucifers

Joseph B. Sieczka


## Abstract

Experiments evaluating the effects of shielded oxyfluorfen applications in direct-seeded broccoli (*Brassica oleracea* var. botrytis) and cabbage (*Brassica oleracea* var. capitata) were conducted at the Long Island Horticultural Research Laboratory in 1991 and 1992. The results show that two applications of oxyfluorfen at rates of 0.03, 0.06 and 0.12 lbs. ai/A were effective in controlling purslane (*Portulaca oleracea*) and lambsquarters (*Chenopodium album*) both years. Some annual grass control [barnyard grass (*Echinochloa crus-galli* (L) Beauv.) and crabgrass (*Digitaria sanguinalis* (L.) Scop.)] was demonstrated in 1991. Crop phytotoxicity was observed both years and was more severe in cabbage than broccoli. Plants grew out of the injury and no yield effects were observed.


## Justification

Resistance to direct-seeding of crucifers in the Northeast is primarily due to the difficulty in controlling weeds. Registered herbicides are relatively effective in controlling annual grasses but generally ineffective on many broadleaf weeds. Oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene] is registered for use on transplanted crucifers. It has good post emergence activity at relatively low rates on a broad spectrum on broadleaf weeds. The purpose of this study was to evaluate the effect of multiple, low rate, shielded applications of oxyfluorfen on weed control and crop response.

## Materials and Methods

Experiments were established in 1991 and 1992 at the Long Island Horticultural Research Laboratory in Riverhead, New York. The experimental design of both experiments was a split plot for weed control/crop phytotoxicity ratings and a randomized complete block for crop yield. The main plots were crops (broccoli and cabbage) and sub plots were herbicide treatments. Pre plant fertilizer was broadcast and incorporated immediately prior to seeding. The amount (lbs/A) of nitrogen, phosphate and potash in 1991 was 100-200-100 and in 1992 was 100-100-100. Side dress nitrogen was applied at a rate of 50 lbs/A when plants were approximately 6 inches tall. Seed was planted 2 inches apart in 34 inch rows. Broccoli was thinned to 8 inches and cabbage to 16 inches. Planting date in 1991 was July 9th and in 1992 was July 7th. Standard irrigation and pest control practices were employed both years.

Main plots were 4 crop rows by 20 feet in 1991 and 4 rows by 18 feet in 1992. Sub plots were 2 rows wide and an unplanted row separated crops within replications and between adjacent replications to minimize the potential for spray drift. Yield data were collected from the center 10 feet of the two row plots. All herbicide applications were made with a tractor mounted sprayer at 30 psi. The pre plant incorporated application of trifluralin [2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine] was applied immediately before seeding. Post emergence applications were made with metal shields on each side of the crop. The area sprayed at the first post emergence application both years was 25.5 inches wide and used the equivalent of 32 gallons/A of spray material. The second post emergence spray in 1991 was 17 inches wide at 25 gallons/A and in 1992 was 12 inches wide at 35 gallons/A.

Ratings on weed and crop phytotoxicity and weed control were made on a zero to ten scale, 1, 3, 7, and 14 days after post emergence applications. A rating of 10 on the phytotoxicity scale represents the most vigorously growing plants of the entire test area. A rating of five represents plants with 50% reduction in vigor compared to the ten. A rating of zero represents dead plants. In weed control, a rating of ten represents 100% weed control (clean plots), and zero indicates no apparent weed control. Plots which had 50% fewer weeds than the weediest plots in the test received a rating of five.

## RESULTS AND DISCUSSION

Crop phytotoxicity from shielded applications of oxyfluorfen was evident in 1991 and 1992 (Tables 1 and 2). The primary injury symptom observed in 1991 was stunting. In 1992, the typical leaf spotting associated with post emergence applications of oxyfluorfen was noted. The injury symptoms increased with increasing rates and were most noticeable after the first application. Cabbage was more susceptible than broccoli. Injury symptoms after the second application were noted in 1991 but were not observed in 1992.

Overall weed control ratings seven days after all post emergence oxyfluorfen applications in 1991 were significantly better than the no chemical control and the trifluralin treatments (Table 1). The weed phytotoxicity ratings in 1992 for common purslane and lambsquarters showed the dramatic effect of post emergence oxyfluorfen applications (Table 2). The effect on common purslane extended throughout the season. Lambquarters control diminished with time, with only the 0.12 lb ai/A rate and the combination of trifluralin and oxyfluorfen at 0.06 lb ai/A providing commercial control at the end of the season. Possibly, a slightly earlier application of the second post emergence spray would have been more effective, especially in cabbage.

Marketable yield of broccoli and cabbage in the no chemical control treatment was significantly lower than the other treatments tested in 1991 (Table 1). The same applied to cabbage in 1992 (Table 2). The marketable yield of the no chemical control and the trifluralin treatments in broccoli were not significantly different from each other. The injury symptoms associated with the oxyfluorfen treatments did not translate into delayed harvest or yield reductions in either crop.

Based on these data, a combination of trifluralin applied PPI followed by an as-needed shielded application of oxyfluorfen at 0.06 lbs ai/A would give broad spectrum weed control in direct-seeded crucifers. Post emergence, shielded, low rate applications of oxyfluorfen may also have potential as an "emergency" strategy in transplanted crucifers.

le 1. The effect of shielded oxyfluorfen applications on crop phytotoxicity and weed control ratings and marketable yield of :coli and cabbage, Riverhead, N.Y. - 1991

| | | Crop Phytotoxicity | | | | Weed Control [a] | | | | Marketable Yield | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 8/3/91 | | 8/20/91 | | 8/3/91 | | 8/20/91 | | Broc | Cab |
| mical [b] | lb ai/A | Broc | Cab | Broc | Cab | Broc | Cab | Broc | Cab | (boxes/A) | (cwt/A) |
| Chemical Control | | 10.0 | 10.0 | 9.0 | 9.0 | 0.0 | 0.0 | 0.0 | 0.0 | 268 | 84 |
| ıd Weeded Control | | 10.0 | 10.0 | 10.0 | 10.0 | 8.8 | 9.0 | 10.0 | 10.0 | 405 | 314 |
| luralin (PPI) | 0.75 | 10.0 | 10.0 | 10.0 | 10.0 | 7.0 | 8.0 | 6.8 | 7.8 | 365 | 299 |
| luralin (PPI) plus oxyfluorfen | 0.03 | 9.5 | 9.7 | 10.0 | 9.5 | 9.0 | 9.3 | 9.0 | 9.0 | 375 | 303 |
| luralin (PPI) plus oxyfluorfen | 0.06 | 7.2 | 7.5 | 9.5 | 9.5 | 9.0 | 9.0 | 9.0 | 9.0 | 395 | 345 |
| luralin (PPI) plus oxyfluorfen | 0.12 | 5.2 | 3.7 | 8.7 | 6.0 | 9.3 | 9.3 | 9.0 | 9.3 | 429 | 384 |
| ıers Protected | | | | | | | | | | | |
| ) (0.05) | | (1.3) | (1.3) | (0.8) | (0.8) | (0.7) | (1.0) | (0.8) | (0.9) | (60) | (54) |

:imary weeds were purslane, buckhorn plaintain and crabgrass.

rifluralin at 0.75 lb/A was applied PPI on 7/9/91. Shielded sprays of oxyfluorfen were made on 7/26/91 and 8/13/91.

ıle 2: The effect of shielded oxyfluorfen applications on crop and weed phytotoxicity, weed control and marketable yield ıroccoli and cabbage, Riverhead, N.Y.-1992

| | | Phytotoxicity Rating (8/7/92) | | | | | | Weed Control Rating (8/26/92) | | | | Marketable Yield | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Crop | | Porol. in | | Cheal. in | | Porol. in | | Cheal. in | | Broc | Cab |
| :mical [a] | lb ai/A | Broc | Cab | Broc | Cab | Broc | Cab | Broc | Cab | Broc | Cab | (boxes/A) | (cwt/A) |
| Chemical Control | | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 213 | 177 |
| ıd Weeded Control | | 10.0 | 10.0 | | | | | 10.0 | 10.0 | 10.0 | 10.0 | 371 | 546 |
| fluralin | 0.75 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 2.3 | 0.0 | 5.8 | 5.0 | 339 | 355 |
| yfluorfen | 0.03 | 10.0 | 9.0 | 0.1 | 0.5 | 4.5 | 5.0 | 8.8 | 9.0 | 5.3 | 4.0 | 490 | 316 |
| yfluorfen | 0.06 | 10.0 | 8.8 | 0.0 | 0.1 | 3.8 | 3.5 | 9.0 | 9.3 | 7.5 | 4.0 | 376 | 317 |
| yfluorfen | 0.12 | 7.5 | 7.5 | 0.0 | 0.0 | 1.3 | 1.4 | 9.9 | 9.8 | 8.6 | 8.0 | 393 | 447 |
| fluralin plus | 0.75 | 9.0 | 9.0 | 0.0 | 0.0 | 3.0 | 2.3 | 9.8 | 9.6 | 8.6 | 9.3 | 396 | 437 |
| xyfluorfen | 0.06 | | | | | | | | | | | | |
| hers Protected | | | | | | | | | | | | | |
| D (0.05) | | (0.9) | (0.5) | (0.2) | (0.3) | (0.9) | (0.9) | (1.0) | (0.3) | (1.7) | (2.5) | (146) | (124) |

Trifluralin at 0.75 lb/A was applied PPI on 7/7/92. Shielded sprays of oxyfluorfen were made on 7/30/92 and 8/20/92.

ytotoxicity scale: 0 = dead plants, 10 = healthy vigorous plants. Weed control scale: 0 = area filled with weeds, 10 = no weeds.

# PREEMERGENCE LINURON FOR HORSERADISH

C.E. Beste, J.P. Donohoe and D.A. Dinkel[1]

Studies were conducted in 1990 and 1992 to determine the efficacy of preemergence linuron on horseradish (Armoracia rusticana Gaertn. 'Eastern'). Horseradish roots were planted under 25 cm height soil ridges and linuron was applied broadcast preemergence on a Norfolk loamy sand soil with 0.7% organic matter.

Linuron at 3.4 kg/ha caused slight horseradish necrosis in mid-season in 1990 but was non-injurious in 1992. Horseradish yields were unaffected by linuron at 0.8, 1.7 or 3.4 kg/ha. Linuron at 0.8 kg/ha provided >90% control of volunteer wheat (Triticum aestivum L.), common purslane (Portulaca oleracea L.), flatsedge (Cyperus odoratus L.) and carpetweed (Mollugo verticillata L).

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# PREVENTIVE MAINTENANCE CAN WORK ON RIGHTS-OF-WAY

J.W. Orr[1]

## ABSTRACT

By practicing "preventive maintenance", the rights-of-way (R/W) manager can reduce future R/W maintenance costs. Vegetation growing on utility R/W requires responsible management. Left un-managed, vegetation will soon grow into energized conductors creating a hazard and interrupting electrical service vital to our modern society (2,3).

The type of vegetation found on a R/W is dependent on such factors as surrounding plant communities, soil type, habitat, past land use and past maintenance operations (5,6,7,9). The R/W manager can plan future vegetation maintenance by careful selection of herbicides and application techniques (5,8). Bramble and Byrnes have shown how different plant communities resist tree invasion (1,2,4). Since we know certain plants are more resistant to tree seedling invasion than others, future plant communities ought to be planned. Therefore, we can and should use "preventive maintenance" to help make the vegetation growing on a R/W easier to manage.

Because the R/W manager influences long term R/W conditions, it is imperative that he chooses wisely the methods and materials that reduce his future maintenance costs. With proper planning, the R/W manager can decrease projected budget expenditures, minimize environmental impacts and improve public relations (8).

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# TURFGRASS ROOT HEALTH RESEARCH: AN HISTORICAL OVERVIEW

T. E. Vrabel[1]

## ABSTRACT

Preemergence control of annual grassy weeds in turfgrass is accomplished with the use of herbicides in the dinitroaniline, pyridine, oxadiazole, organophosphate, and benzoic acid classes of herbicides. The modes of action of the majority of these compounds involve the disruption of cell division and the inhibition of root and shoot growth. For over 25 years, weed scientists have evaluated these compounds not only for herbicidal efficacy but also for their impact on turfgrass root health and overall turf quality.

In the 1960's and 70's, methodology of root health research mainly involved investigating the effect of herbicide application to newly planted sod strips or plugs. Herbicides were applied to sod before cutting and transplanting or were applied to the soil immediately before laying or to the sod immediately after laying. Research was also conducted investigating the impact of several years of herbicide application on turf quality and density. Results of these studies showed that several dinitroaniline, organophosphate, and benzoic acid herbicides could temporarily inhibit turfgrass root growth and repeated applications could detrimentally impact turf quality.

During the 1980's, the majority of research shifted to investigating the impact of herbicide application on root strength. In these investigations, metal frames of various designs were laid in the soil before seeding or sodding. Following turf establishment, herbicide applications were made (usually during the spring following frame insertion), and the force needed to break the frames from the ground was measured using several types of sod pulling devices. This research showed that spring herbicide applications to cool season turf species seeded the previous fall could greatly reduce turf root strength, turf density, and overall turf quality. Effects to turfgrass established for at least one year were less severe. Research during this period also showed that warm season grasses such as bermudagrass (Cynodon dactylon (L.) 'Pers.') CYNDA were more adversely impacted by herbicide applications than cool season grasses such as Kentucky bluegrass (Poa pratensis L.) POAPR, tall fescue (Festuca arundinacea 'Schreb.') FESAR, and creeping bentgrass (Agrostris palustris 'Huds.') AGRPA because pegging of runners could also be inhibited.

Recent research has focused on the effects on root morphology of herbicide applications. In these studies, sod discs are cut, planted onto a sand-based medium, and treated with a herbicide. At predetermined intervals, the sand is washed from the root system and evaluated for root length, morphological characteristics, and dry weight. This research has shown that pyridine herbicides can cause detrimental morphological effects to turf roots that are similar in appearance to those found with dinitroaniline compounds.

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# TOLERANCE OF COOL-SEASON TURFGRASS SPECIES TO HERBICIDES

**P. C. Bhowmik**[1]

## ABSTRACT

One of the important tools in any successful weed management program is the use of preemergence herbicides. Dinitroaniline herbicides such as benefin, pendimethalin, and trifluralin are the leading herbicides. Other preemergence herbicides include bensulide, DCPA, and oxadiazon, including two recent additions: dithiopyr and prodiamine. In general, Kentucky bluegrass (Poa pratensis L.), perennial ryegrass (Lolium perenne L.), red fescue (Festuca rubra L.) and other cool-season turfgrasses are tolerant to most of these herbicides. Some species may be susceptible to a herbicide. These herbicides provide residual preemergence control of many weeds. The residual activity is dependent upon the threshold concentration of the applied herbicide and its rate. Repeated applications of these herbicides can cause restricted root growth, reduced tillers and rhizomes, and stand thinning.

In a 'Penncross' creeping bentgrass (Agrostis palustris Huds.) trial in 1986, quinclorac at 0.56 to 2.2 kg $ha^{-1}$, applied postemergence, injured (13 to 55%) bentgrass, although the treated bentgrass recovered later in the season. Final bentgrass quality was unaffected. Pendimethalin at 0.8 kg $ha^{-1}$ did not injure bentgrass. However, the highest rate (3.4 kg $ha^{-1}$) of pendimethalin gave initial bentgrass injury (20%) and resulted in stand thinning. It prevented the stolons from normal rooting and resulted in increased stolons without roots. Fenoxaprop at 0.13 kg $ha^{-1}$, applied postemergence, did not injure bentgrass.

During 1987-89, turfgrass injury (15 to 38%) and thinning of Kentucky bluegrass was noted with the premix combination (1:2 ratio) of trifluralin and benefin at 4.5 kg $ha^{-1}$. Benefin at 4.5 kg $ha^{-1}$ also injured Kentucky bluegrass. Higher rates of benefin (3.3 and 4.5 kg $ha^{-1}$) and the premix combination of trifluralin and benefin (3.4 and 4.5 kg $ha^{-1}$) inhibited tiller production and rhizome growth of Kentucky bluegrass 4 and 8 weeks after application. Pendimethalin and prodiamine did not reduce tiller production or rhizome development and growth.

During 1989-91, dithiopyr treatments (0.3 to 1.1 kg $ha^{-1}$) did not reduce the quality or color of 'Baron' Kentucky bluegrass. Root regrowth, tiller and rhizome numbers were unaffected with the 1.1 kg $ha^{-1}$ rate. Single annual spring applications of dithiopyr for three consecutive years showed no adverse effects on Kentucky bluegrass. Perennial ryegrass was tolerant up to 1.7 kg $ha^{-1}$ of dithiopyr after single annual application for three years. Root regrowth, tiller and rhizome development were unaffected. On a putting green, 'Penncross' bentgrass was tolerant to dithiopyr up to 1.1 kg $ha^{-1}$. Dithiopyr rates up to 1.1 kg $ha^{-1}$ did not adversely affect bentgrass color, quality, stolon development, or root regrowth. Single annual spring applications of dithiopyr (0.3 to 1.1 kg $ha^{-1}$) for four consecutive years did not reduce overall quality of bentgrass.

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# REVIEW OF CREEPING BENTGRASS TOLERANCE TO HERBICIDES

Peter H. Dernoeden[1]

## ABSTRACT

Most commercially available herbicides are known to discolor or severely damage creeping bentgrass (Agrostis palustris Huds.), particularly bentgrass grown on putting greens. Herbicides that creeping bentgrass normally tolerates may lose their margin of safety when applied during periods of heat or drought stress or when applied to poorly drained putting greens where root system depth is restricted to the upper inch of soil. Creeping bentgrass turf maintained under low nitrogen fertility, very low mowing (<5/32 inches), or putting greens treated with plant growth regulators also are more susceptible to herbicide injury. There are few herbicides registered for use on creeping bentgrass, and even fewer for putting greens. It is important to note that the relative safety of labelled herbicides applied to vegetatively propagated, and many of the new seeded creeping bentgrass cultivars, is unknown. All herbicides applied to creeping bentgrass should be field tested under local conditions and bentgrass cultivars before they are used on a wide scale. Some of the more commonly used herbicides labelled for creeping bentgrass turf are listed in Table 1. Of those listed, only bensulide, bensulide + oxadiazon, dithiopyr, MCPP, and specially formulated "bentgrass" mixtures of 2,4-D + MCPP + dicamba are labelled for use on putting greens. Herbicides such as fenoxaprop and ethofumesate show promise for use on putting greens, but are only labelled for use on bentgrass tees or fairways at the present time.

Bensulide-containing products have been used for decades for the purpose of preemergence crabgrass (Digitaria spp.), goosegrass (Eleusine indica [L.] Gaertn.), and annual bluegrass (Poa annua L.) control on greens. Bensulide, however, provides erratic annual grass weed control in some regions. Recent research indicates that perennial types of P. annua are not controlled by bensulide. The package-mix of bensulide plus oxadiazon was first used on putting greens in the early 1980's. This product provides excellent goosegrass control, and fairly good crabgrass control. Some bentgrass yellowing may occur within 10 to 14 days of application.

Dithiopyr was labelled for use on creeping bentgrass greens, and most other turfgrasses in 1991. Dithiopyr effectively controls goosegrass preemergence and crabgrass both pre and early postemergence. For putting greens, dithiopyr should be applied in early spring as a preemergence treatment. Because of its residual effectiveness, dithiopyr can be applied as early as February or March without loss of activity. Reports of dithiopyr injury to bentgrass greens have been few thus far, and restricted to overlapping spray error, particularly on poorly drained greens with shallow bentgrass root systems. Dithiopyr, however, can yellow bentgrass if applied during warm periods. June applications, when daytime temperatures exceed 90F, can cause extensive damage to both bentgrass and annual bluegrass on greens. Hence, it is best to apply this product in March or April as a preemergence treatment for crabgrass or goosegrass control on greens. The early preemergence timing of dithiopyr will also minimize potential late summer overseeding problems with bentgrass.

White clover (Trifolium repens L.) and mouseear chickweed (Cerastium vulgatum L.) are among the most common broadleaf weeds on greens, and they are generally safely controlled with MCPP. MCPP applied during summer will yellow putting green turf, and when applied alone, MCPP provides relatively poor control of most other broadleaf weeds. When several different broadleaf weed species colonize greens, specially formulated mixes, known as a "bentgrass formula" of 2,4-D + MCPP + dicamba is used. These special mixes contain about 80% less 2,4-D than "regular" prepackage mixtures. This is because 2,4-D can be extremely phytotoxic to creeping bentgrass. Use of these "bentgrass formulations", however, are frequently associated with bentgrass yellowing or severe damage if not properly applied.

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Table 1. Some herbicides that are labelled for use on creeping bentgrass.

| Chemical Name | Trade Name(s) | Bentgrass Safety Comments/Uses* |
|---|---|---|
| Broadleaf Herbicides | | |
| 2,4-D + MCPP + Dicamba | Bentgrass formulations of Three-Way; Trexsan; Trimec; Others | May be used on greens, tees, fairways. Likely to cause some yellowing. |
| Dicamba | Banvel | May be used only on tees and fairways. May stunt or discolor bentgrass. |
| MCPP | Lescopex, Mecomec, others | Good safety, but can cause some yellowing on greens. |
| Postemergence Grass Herbicides | | |
| Fenoxaprop | Acclaim | Multiple-low rates used for crabgrass or goosegrass control on bentgrass mowed above 0.25 inches. Can discolor for 2 weeks. |
| Chlorsulfuron | Lesco TFC | Used for perennial ryegrass or tall fescue control in bentgrass tees or fairways. Controls some broadleaf weeds. |
| Ethofumesate | Prograss | Used for annual bluegrass control in bentgrass fairways. Likely to stunt and discolor bentgrass, especially when used in multiple applications. |
| Preemergence Herbicides | | |
| Prodiamine | Barricade | For preemergence crabgrass and goosegrass control. Do not apply to creeping bentgrass maintained below 0.50 inches. |
| Bensulide | Betasan, Lescosan, Presan, others | For preemergence crabgrass and annual bluegrass control on greens, tees or fairways. |
| DCPA | Dacthal | Not recommended for use on greens. Known to be safe on Penncross. |
| Dithiopyr | Dimension | For preemergence crabgrass and goosegrass control on greens, tees or fairways. Do not apply to poorly drained greens or bentgrass turfs with short and chronically weak root systems. |
| Isoxaben | Gallery | Do not use on putting greens. Apply late summer or early fall to fairways for preemergence broadleaf weed control, especially winter annuals. |
| Bensulide + Oxadiazon | Scott's Goosegrass/ Crabgrass Control | For preemergence goosegrass and crabgrass control on greens, tees or fairways. May cause some yellowing on greens. |
| Siduron | Tupersan | May be applied to newly seeded Penncross or Seaside. Do not use on greens. |
| Others | | |
| Bentazon | Basagran | For yellow nutsedge control in bentgrass tees or fairways. |

*The relative safety of these herbicides on vegetatively propagated and many of the newer, seeded bentgrass cultivars is unknown.

# SAFETY OF HERBICIDES ON OVERSEEDED AND NEWLY SEEDED TURFGRASS

J. C. Neal[1]

## ABSTRACT

Limited options are available for weed control in newly seeded turf. Historically dicot weeds have been controlled with bromoxynil; however, recent label restrictions preclude its use on most turf areas. Fortunately, once seedling turf has been mowed three or four times, other dicot herbicides may be safely used. As a result, dicot weeds are generally not a great problem in new seedings. In contrast, most graminicides have a narrow margin of safety on young turf; therefore, annual grasses remain the most persistent and difficult to manage weeds infesting new seedings.

The only preemergent graminicide with no pre-seeding or post-seeding restrictions is siduron. All other preemergent herbicides have specific treatment-to-seeding and seeding-to-treatment intervals which must be observed. These intervals differ by product, rate, formulation, and turfgrass species. Recent research has also shown regional and yearly variability in the longevity of soil residues from these herbicides. Under warm, moist year, residues dissipate more rapidly than in a dry year. When dry weather persists through the growing season the only reliable method for predicting whether soil residues may interfere with seedling establishment is to conduct a bioassay. The seeding-to-treatment intervals seem to be more predictable but still vary by product, rate, and the rate of turf establishment.

Similar seeding-to-treatment and treatment-to-seeding intervals guide the use of postemergent graminicides. As most of our postemergent herbicides have relatively short soil residuals, the latter interval is usually easily defined. However, the seeding-to-treatment interval is affected by turf species, herbicide, rate, additives, and environmental conditions (which affect the rate of turf establishment). Where herbicide injury is likely to occur, another consideration is: what will decrease turf quality more - the weed or the herbicide. This decision is a site-specific issue and will depend on the type of turf, its use (sod production, home lawn, etc.), and the tolerance of the turf manager and owner (or greens committee) to weeds and turf injury.

One topic deserving more attention and discussion is a definition of "established turf", as this term is used to describe the developmental stage when herbicides may safely be used. To often the safe intervals are described in calendar days or months, when a more appropriate measure would be a developmental stage when turf will tolerate the herbicide application. Recently, one postemergent graminicide has characterized the appropriate interval based on the number of tillers present. Other methods employed have included the number of mowings, the point at which stolons develop, and % ground cover. The most appropriate method will depend on the herbicide and turf species. More clearly defined and consistent terminology would help turf managers and those who provide weed control recommendations to avoid turf injury resulting from inappropriate herbicide usage.

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# TURFGRASSES AND PLANT GROWTH REGULATORS SAFETY

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## ABSTRACT

For decades, chemicals such as Maleic hydrazide have been available for use on turfgrasses to suppress seedhead emergence and reduce vegetative growth. Early chemicals were primarily mitotic inhibitors; and therefore, growth regulation was mostly a function of reduced cell division at all plant meristems. As a result, decreases in tillering, rooting, and stolon and rhizome growth have been reported as typical side effects of growth regulator use. In addition, some degree of foliar color change has frequently been observed. Depending on the species being treated, the chemical used, the rate, and time application all influence whether the plant responses cited above are either magnified or diminished.

More recently, chemicals have been commercialized that primarily reduce growth via the inhibition of gibberellic acid. Thus, reduction of cell elongation is primarily responsible for reduced growth rather than a reduction in cell division. A rate dependent foliar discoloration has frequently been reported for turf treated with gibberellic acid inhibitors. However, decreased rooting and tillering have not been shown; and, in some studies, rooting and tillering have increased for treated turf. Resistance to wilting and greater water use efficiency have also been reported. The growth suppression due to inhibition of gibberellic acid can also be antidoted by foliar applications of gibberellic acid.

Although little information exists on the influence of environmental conditions on growth regulator safety, it has been observed that greater injuries (both discoloration and thinning) more frequently occur if turf is treated while under heat and/or moisture stress.

The safe use of plant growth regulators can also be influenced by other chemicals. For example, decreases in safety have been found when mitotic inhibitors have been applied in combination with gibberellic acid inhibitors. Also, gibberellic acid inhibitors have been observed to cause more injury when used with fungicides that also have been shown to interfere with gibberellin biosynthesis. Other fungicides and nitrogen fertilizers have been shown to improve growth regulator safety.