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# COMPARISON OF ROPE-WICK AND BROADCAST TREATMENTS FOR CONTROL OF CANADA THISTLE AND TALL IRONWEED

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ABSTRACT OF THESIS

# COMPARISON OF ROPE-WICK AND BROADCAST TREATMENTS FOR CONTROL OF CANADA THISTLE AND TALL IRONWEED

Tall ironweed (*Vernonia altissima*) and Canada thistle (*Cirsium arvense*) control in cool season grass pastures was evaluated in 2007 and 2008. Tall ironweed was evaluated in Fayette and Boone Counties, KY and Canada thistle was evaluated at Spindletop Research Farm. Herbicides applied selectively with a rope-wick were compared to a broadcast foliar spray. Treatments were a broadcast treatment, of aminopyralid + 2, 4-D and six rope-wick treatments: aminopyralid at three concentrations, glyphosate, triclopyr and clopyralid at one concentration each. The Boone County location had five broadcast foliar treatments: aminopyralid at three rates, triclopyr + fluroxpyr, and 2,4-D + triclopyr. The Canada thistle study consisted of the same six rope-wick treatments as the Fayette County tall ironweed study. A broadcast treatment of aminopyralid at 70 g a.e./ha was included in 2008. Studies were evaluated 1, 2, 3, 4, 8 and 52 weeks after treatment. Aminopyralid plus 2,4-D provided 86% control of tall ironweed 52 WAT. Aminopyralid at 20% v/v controlled 65% of tall ironweed. Canada thistle control 52 WAT ranged from 0 to 25% control for the six rope-wick treatments.

KEYWORDS: Tall ironweed, Canada thistle, rope-wick, broadcast foliar spray, pasture weed control

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____May 5, 2009___

COMPARISON OF ROPE-WICK AND BROADCAST TREATMENTS FOR CONTROL OF CANADA THISTLE AND TALL IRONWEED

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______May 5, 2009_________

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THESIS

Daisy M. Fryman

The Graduate School

University of Kentucky

2009

COMPARISON OF ROPE-WICK AND BROADCAST TREATMENTS FOR CONTROL OF CANADA THISTLE AND TALL IRONWEED

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THESIS

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A thesis submitted in partial fulfillment of the requirements of the degree of Master of Science in the College of Agriculture at the University of Kentucky

By

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Table of Contents

List of Tables

# CHAPTER 1

# INTRODUCTION

Rope-wick selective herbicide application methods have been used to target undesirable species while having little to no harmful effect on the desirable plant species. Rope-wick applicators have been used in a variety of cropping systems to eliminate weeds, where a broadcast application would be detrimental to the crop if there were any type of herbicide contact or if broadcast treatments were not available. Rope-wick or wipe-on types of herbicide applicators were broadly used in cotton, soybeans, horticultural crops, turf, and pasture (Derting, 1981b). Wiping devices were especially used in soybeans and cotton for weeds that escaped control from other methods (Gebhardt and Fornstrom 1985). Wiper application methods increased with the availability of glyphosate herbicides (Derting, 1987) primarily for johnsongrass (*Sorghum halepense*) control in cotton and soybeans.

Currently, most pasture herbicides are only labeled for use in grass pastures. Therefore, herbicides applied to grass pastures inter-seeded with legumes poses a large risk of damage to the legume species. A recent survey of county extension agents conducted in 2007 indicated that killing clover was the number one concern of producers and one of the primary reasons weeds were not controlled by herbicides in pastures (Green 2007). The second common reason for no weed control was herbicide expense. Green (2007) further found that approximately 15% of Kentucky pastures are treated with herbicides, while 61% of pastures are mowed one to two times per year.

A rope-wick applicator can be utilized to eliminate injury to desirable forages, such as clover, so a herbicide treatment may be applied to more upright weed species, such as tall ironweed and Canada thistle (Andersen et al. 1982). Currently, University of Kentucky cooperative extension service does not recommend rope-wick applicators for weed control on perennial pastures. Previous research on rope-wick applicators or other wiping technology include Canada thistle (*Cirsium arvense*) (Grekul et al., 2005; Krueger-Mangold et al., 2002; Boerboom and Wyse 1988), leafy spurge (*Euphorbia esula*) (Regimabal and Martin 1981; Moomaw and Martin 1990), and common reed (*Phragmites australis*) (Kay 1995), larkspur (*Delphinium* ssp.) (Ralphs et al. 1991), giant burweed (*Sparaganium eurycarpum*) (Leif and Oelke 1990), cogongrass (*Imperata cylindrica*) (Willard et al. 1997).

The use of rope-wick applicators for pasture and rangeland has been minimal due to the ease of using a broadcast application. Kentucky pastures utilized for beef production have a high percentage of natural white clover (*Trifolium repens*) as well as some inter-seeded red clover (*Trifolium pratense*) in pastures and hayfields. Inter-seeded and natural clovers are utilized in Kentucky beef pastures to increase cattle gains as well as dilute fescue toxicity from the endophyte infected Kentucky 31 tall fescue (*Festuca arundinacea)* found across the state. Pasture managers have no way to chemically control weeds in their pastures without killing or severely causing injury to the clover species.

Rope-wick applicators come in many different designs, which encompass size of the unit, rope fiber properties, and recirculating systems. There are four basic designs of rope-wick applicators: SPWA, multiple RWA, pressurized RWA, and recirculating double pipe wick (Derting 1987). The most commonly used applicator was the SPWA, which fitted polyester/acrylic diamond braid wicks approximately 10 to 20 cm long, to a

PVC pipe. In this system, herbicide mixtures were gravity fed from the pipe into the rope material.

**Cananda Thistle (*Cirsium arvense*)**

Canada thistle (*Cirsium arvense*) is a perennial weed in agronomic crops, pastures, and roadsides in Kentucky. "In Kentucky, Canada thistle infestations are more prominent around the central part of the state and north of I-64 (J. D. Green, University of Kentucky Weed Science Extension Specialist)." Canada thistle was reported on 33 noxious weed lists (Skinner et al. 2000), from the 48 contiguous states and southern provinces of Canada. A highly competitive weed, Canada thistle establishes in most areas by seed first but then maintains and increases its population with a creeping adventitious root system. Several researchers have reported that Canada thistle causes yield reductions in crops, such as barley and wheat (Haggar et al. 1986), and reduces forage availability and production (Reece and Wilson 1983).

Mowing, biological control, chemical control, competitive seeding of grasses and other crops has been evaluated for Canada thistle control. Many of these control methods are combined and used in integrated weed management strategies. Current herbicide control options for Canada thistle in the University of Kentucky Cooperative Extension Service AGR-172 list dicamba, glyphosate and metsulfuron as fair control, which gives suppression or partial control, while it list triclopyr and aminopyralid as good to excellent control (Green et al., 2006).

Reece and Wilson (1983) conducted field experiments on Canada thistle and musk thistle (*Carduus nutans*) control in Nebraska on a sub-irrigated meadow that utilized a combination of nitrogen fertilizers rates and herbicide treatments. They reported that all herbicide treatments were effective on both thistles with or without fertilizer. They indicated that fertilized plots had a greater thistle biomass than the unfertilized check in the three-year experiment. They further reported that ammonium nitrate with either clopyralid in 1978, clopyralid + 2, 4-D in 1979 and dicamba + 2, 4-D in 1980 reduced grass biomass compared to non-fertilized plots; however, there was no determination that biomass was reduced due to herbicide injury, which was observed in some treatments in 1978 (Reece and Wilson 1983).

Donald (1993) studied the effectiveness of long-term herbicide treatments applied in late September for the control of Canada thistle shoot density on non-cropped, untilled abandoned farmland. Clopyralid, glyphosate and picloram were effective in reducing Canada thistle at certain high rates in the first two years of the trial. The fall-applied treatments of clopyralid and picloram took fewer years of treatments to reduce shoot density than did glyphosate or dicamba. Clopyralid at 840 g/ha or picloram at 560 g/ha applied in the fall for three consecutive years inhibited, or almost prevented, shoot emergence the third growing season, while glyphosate and dicamba did not reduce shoot emergence.

Miller and Lym (1998) conducted several field experiments on the control of Canada thistle with herbicides and cultivation treatments in corn and soybeans. Photoperiod determinations of Canada thistle and clopyralid absorption and translocation at different stages of growth were evaluated. The herbicide and cultivation treatments resulted in clopyralid and bentazon having 42% and 44% control 4 MAT in corn and soybeans, respectively. They reported no crop injury or yield loss from the herbicide or cultivation treatments. Further, Miller and Lym (1998) reported, that on average, Canada thistle seedlings required 15 hours of photoperiod to reach bolt and this experiment confirmed the work of Haderlie et al. (1991). Miller and Lym (1998) reported Canada thistle absorption and translocation of $^{14}$C-clopyralid was greater in the rosette stage than in the bolt stage 24 hours after treatments, but found no difference in absorption or translocation 48 and 72 hours after treatment. Hunter (1995) reported that $^{14}$C-glyphosate applied at the bud and rosette stage had no affect on the amount of $^{14}$C in the treated leaf; however, it did affect shoot distribution.

Wilson and Kachman (1999) conducted an experiment to compare mowing and herbicide treatments for control of Canada thistle during the establishment of perennial grasses in pasture sites. Their results indicated that pre-plant cultivation increased perennial grass establishment 12 months after seeding. Three years after seeding Canada thistle control was greater than 90% in pre-plant cultivation, which was comparable to herbicide treatments of clopyralid.

Beck and Sebastian (2000) published research comparing fall-applied herbicides alone and with 1, 2, or 3 mowings on sub irrigated and upland pastures in Colorado. Their results showed no advantages of control by mowing with treatments of picloram or chlorsulfuron at either site; however, control of Canada thistle increased at the upland site with 2 to 3 mowings before treatment with dicamba. Clopyralid + 2,4-D also increased control when combined with 2 to 3 mowings before application (Beck and Sebastian 2000).

Enloe et al. (2007) established ten studies to directly compare aminopyralid efficacy to current recommendations. The studies were conducted in Colorado, Nebraska, North Dakota, South Dakota, and Wyoming. They reported that Canada thistle control ranged from 34 to 97% 1 YAT for all herbicide treatments. Furthermore, they reported that Canada thistle control was similar to all aminopyralid rates and time of application did not influence the aminopryralid efficacy.

The use of rope-wick applicators for Canada thistle control is not currently recommended in Kentucky. No studies were reported in the United States using a rope-wick applicator for Canada thistle control. However, there were several studies conducted using wiping technologies on Canada thistle. One study evaluated pasture forage responses to wiping with various herbicides in Alberta, Canada (Grekul et al., 2005). They reported that in 2005 that wiping 33% v/v of glyphosate decreased live Canada thistle density by 68 to 80%, and that thistle biomass remained lower for 2 years. Further findings of this study showed that clopyralid had a significantly lower biomass and shoot density of Canada thistle than the check, in 2001, but showed no significant difference in 2002 (Grekul et al., 2005). They further reported that 2 years after treatment that the rapid decrease of Canada thistle shoots were likely due to drought in 2001 and not from herbicide treatment.

Krueger-Mangold et al. (2002) conducted an experiment that evaluated Canada thistle control in waterfowl production areas with wick treatments during summer and fall. They found that wiping treatments of glyphosate reduced biomass more than broadcast treatments, but was still similar to the untreated area. Fall wicking treatments of glyphosate decreased Canada thistle densities consistently. Conversely, summer wicking treatments increased Canada thistle population by 10 plants/m$^2$ 1 YAT (Krueger-Mangold et al., 2002).

Boerboom and Wyse (1988) conducted a field experiment with the use of roller and rope-wick applicators to evaluate the control of Canada thistle in birdsfoot trefoil (*Lotus corniculatus*). They reported that glyphosate and clopyralid applied in double-applications with a roller application had greater control than MCPA 400 days after treatment. Single treatments controlled less Canada thistle than double repeated treatments, however, additional treatments showed no significant increase in control. Treatments of picloram showed 28 to 75% injury to birdsfoot trefoil, but controlled 90 to 100% of Canada thistle 30 days after treatment and 65 to 99% 400 days after treatment (Boerboom and Wyse 1988).

Prior research has utilized the chemical control recommendations in Kentucky, however, there are several herbicides that were mentioned in the literature that are not labeled for use in Kentucky.

**Tall Ironweed (*Vernonia altissima*)**

Tall Ironweed (*Vernonia altissima*) is a perennial dicotyledon native to the United States (U.S. Department of Agriculture Agricultural Research Service 1970). It is commonly found in over-grazed pastures, as well as wet bottoms and upland sites in Kentucky (Marshall et al. 2006b). A 2007 survey of Kentucky agriculture extension agents ranked tall ironweed as the most problematic weed in Kentucky pastures (Green 2007).

Tall ironweed ranges in size of 1 to 3 m tall, with leaves alternating along the stem. Leaves are lanceolate and 15 to 25 cm in length and 3 to 7 cm in width (Gleason and Cronquest, 1963). Tall ironweed flowers from August through September in

Kentucky, producing reddish-purple flowers arranged in an open inflorescence that can either be flattened, concave, or irregular with 15 to 30 florets (Gleason, 1952). Tall ironweed reproduces by seeds and vegetative buds of the root crowns (Mann et al., 1983).

Current herbicide control options for tall ironweed in the University of Kentucky Cooperative Extension Service bulletin AGR-172 lists metsulfuron, dicamba plus 2,4-D and glyphosate as a suppression or partial control measure and list aminopyralid, aminopyralid plus 2,4-D, triclopyr, fluroxypyr, and dicamba as having excellent or good control (Green et al. 2006). Other recommendations for control of tall ironweed include mowing in mid-summer followed by herbicide treatment in late summer to early fall (Marshall, 2006a). All current chemical recommendations in Kentucky have been evaluated in past research, however, there are some herbicides not labeled for use in Kentucky.

Peters and Lowance (1979) conducted a field experiment to compare 2, 4-D ester, glyphosate and picloram for tall ironweed control over three years. They reported inconsistent control of tall ironweed with 2, 4-D and glyphosate over the three years while picloram consistently reduced tall ironweed stands from 79 to 100% (Peters and Lowance 1979).

McCarty and Linscott (1962) conducted several experiments to study the control of broadleaf weeds in pastures by spraying 2,4-D and mowing at different time intervals throughout the summer and fall. They reported that spraying 1 lb/A of 2,4-D repeated over several years in early to mid-summer gave excellent control of Baldwin's ironweed (*Veronia baldwinii*, Torr.). They found that mowing had little to no effect on ironweed populations and the late July and August herbicide treatments dates were ineffective for control of Baldwin's ironweed. Treatments that continued for several years reduced ironweed populations essentially to zero; however, treatments that were discontinued resulted in an increase of Baldwin's ironweed population. They furthered reported that 2,4-D ester formulation appeared to be more effective than the amine salt, however, there was no significant difference. The greatest level of control obtained in 5 years of treatment with 2,4-D ester was 98% when applied in June and the lowest control was 55% when applied in August.

Mann et al. (1983) reported that under greenhouse conditions that the regrowth of basal buds on tall ironweed seedlings needed to be at least 3 to 4 weeks of age for regrowth to occur after clipping. Triclopyr had the greatest reduction in regrowth, while 2,4-D ester had greater tall ironweed growth 45 and 47 weeks after treatment. Two years of consecutive herbicide treatments resulted in the greatest reduction of tall ironweed with triclopyr. They further reported that fosamine, dicamba, 2,4-D (alkanolamine) and clopyralid did not inhibit regrowth of basal buds the year after treatment (Mann et al., 1983).

Marshall et al. (2006b) conducted a field experiments on the efficacy of fall-applied herbicides on established stands of tall ironweed after a midsummer mowing and further assessed the impact of herbicide treatments on red clover establishment. They reported 93 to 99% tall ironweed control 8 MAT with treatments containing triclopyr, and less than 60% control 12 MAT for dicamba. They reported that red clover dry matter yields were significantly greater with triclopyr + 2,4-D than triclopyr + clopyralid. They further stated that red clover dry matter yields were significantly lower for herbicide treated plots compared to the nontreated control, except for triclopyr + 2,4-D.

**Rope-wick or wiping treatments evaluated on other weed species.** Willard et al. (1997) conducted an experiment that utilized rope-wick treatments for control of cogongrass in Florida. They reported control of cogongrass was increased with a 50% solution rather than 33%, and greater control was obtained with two passes over the cogon grass, rather than one.

A hand-held wiper and spot-spray treatments of glyphosate were evaluated for the control of larkspur in Idaho. Researchers reported that both spot-spray and hand-held wiper treatments of glyphosate killed almost all larkspur in the plots. However, the hand-held wiper on average took 1.9 seconds longer per plant than the spot-spray treatments (Ralphs et al. 1991).

Leif and Oelke (1990) evaluated glyphosate rope-wick treatments for control of giant burweed. They reported that the greatest level of control was with 30% solution of glyphosate, however, a 5% solution caused injury of 20% or less. They concluded that 30% solution of glyphosate applied with a rope-wick reduced giant burweed growth, and could be utilized in crops that were not tolerant to 2,4-D or bentazon at rates needed to control giant burweed (Lief and Oelke 1990).

# CHAPTER 2: CANADA THISTLE CONTROL WITH ROPE-WICK APPLICATION

## INTRODUCTION

Canada thistle (*Cirsium arvense*) is a troublesome perennial weed in agronomic crops, pastures and roadsides in Kentucky. "In Kentucky, Canada thistle infestations are more prominent around the central part of the state and north of I-64 (J. D. Green, University of Kentucky Weed Science Extension Specialist)." Canada thistle was reported on 33 noxious weed lists in 2000 by Skinner, Smith and Rice, who compiled a noxious weed list from the 48 contiguous states and southern provinces of Canada. A highly competitive weed, Canada thistle establishes in most areas by seed first, then maintains and increases its population with a spreading adventitious root system. Yield reduction from Canada thistle was reported in barely and wheat (Haggar et al. 1986). Forage availability and yield was also reduced by Canada thistle (Reece and Wilson 1983).

Previous methods evaluated for Canada thistle control are chemical and competitive seeding of grasses (Wilson and Kachman 1999) and other crops (Boerboom and Wyse 1988; Schreiber 1967). These control methods were combined and used in integrated pest management strategies. Current herbicide options in Kentucky for Canada thistle control and suppression are dicamba, triclopyr, metsulfuron, aminopyralid, glyphosate and combinations of the aforementioned herbicides (Green et al., 2006).

Enloe et al. (2007) compared aminopyralid efficacy to current recommendations in Colorado, Nebraska, North Dakota, South Dakota, and Wyoming. They reported that Canada thistle control one year after treatment was significant for all aminopyralid rates and application time did not influence efficacy.

The use of herbicide in rope-wick applicators for Canada thistle control has no current recommendations in Kentucky. No studies have been reported in the United States with rope-wick applicator for Canada thistle control. However, several studies were conducted using wiping technologies on Canada thistle in other countries. One study evaluated pasture forage responses to wiping with various herbicides (Grekul et al., 2005). They reported that in 1999 the glyphosate increased mortality and thistle biomass remained lower for 2 years after treatment. They further reported that 2 years after treatment that the rapid decrease of Canada thistle shoots was likely due to drought and not from herbicide application. Further findings of this study showed that clopyralid had a significantly lower biomass and shoot density than the check, in 2001, but showed no significant difference in 2002 (Grekul et al., 2005). An additional experiment conducted by Krueger-Mangold et al (2002) evaluated the use of wiping method and reported wiping treatments versus broadcast treatments of glyphosate had a greater reduction of Canada thistle biomass, but was still similar to the untreated area of Canada thistle (Krueger-Mangold et al., 2002).

Boerboom and Wyse (1988) conducted a field experiment with the use of roller and rope-wick applicators to evaluate the control of Canada thistle in birdsfoot trefoil (*Lotus corniculatus*). They reported that glyphosate and clopyralid applied in double-applications with roller had greater control than MCPA 400 days after treatment. Single repeated treatments controlled less Canada thistle than double repeated treatments, however, additional treatments showed no significant increase in control. Treatments of picloram showed 28 to 75% injury to birdsfoot trefoil, but controlled 90 to 100% of

Canada thistle 30 days after treatment and 65 to 99% 400 days after treatment (Boerboom and Wyse 1988).

The objectives of this study were to (1) evaluate the utility of a rope-wick applicator for applying herbicide to Canada thistle, and (2) evaluate labeled herbicides for use in rope-wick applicators to provide Canada thistle control.

## MATERIAL AND METHODS

Two experiments were established in early June of 2007 and 2008 at Spindletop Research Farm in Lexington, Kentucky. The site had a dense infestation of Canada thistle of about 10 plants $m^{-2}$. The 2007 site had no previous Canada thistle control experiments. The 2008 site was placed in an area where previous experimental trials were conducted. Both sites were known to have Canada thistle since the mid 1970's. In the past ten years Canada thistle has been the dominant species, with little to no control. Previous crops at this site were corn (*Zea mays L.*), tall fescue (*Festuca arundinacea*) and red clover (*Trifolium pratense*).

The experimental design each year was a randomized complete block with four replications. Plot size for the 2007 trial consisted of a 1.5 m by 12.2 m area with 0.75 meter running check between plots. Plot size for the 2008 trial consisted of 3 m by 12.2 m area with 1.5 m untreated check between plots.

Six rope-wick treatments of aminopyralid (applied as Milestone) at 1, 10 and 20% v/v, glyphosate (applied as Roundup Weather Max) at 50% v/v, triclopyr (applied as Remedy Ultra) at 20% v/v, and clopyralid (applied as Stinger) at 20% v/v. The 2008 treatments consisted of the same treatments as 2007 plus a broadcast treatment of aminopyralid (Milestone) at 70 g a.e. per ha with a nonionic surfactant at 0.25%. Herbicides were applied when the Canada thistle reached a height of at least 30 cm and were in a pre-bloom growth stage. The 2008 broadcast treatment was applied using an ATV mounted carbon dioxide pressurized plot sprayer with flat fan nozzles at a pressure of 275 kPa with a 3 m boom at 168 L/ha. Rope-wick selective treatments were applied using an ATV with a front mounted, height adjustable 1.5 m rope-wick. Rope-wick selective treatments were applied on a volume by volume basis with the rope-wick bar being set at a height of 20 cm above the ground. Treatments for 2007 and 2008 are described in Table 2.1.

Percent visual control of Canada thistle was evaluated 1, 2, 3, 4, 8, and 52 weeks after treatments (WAT) were applied. Percent visual control ratings 1, 2, 3, and 4 WAT account for herbicide dose response symptomology rather than actual control. Herbicide symptomology evaluated was bending and twisting of stems and petioles, swelling and elongation of stems, and leaf cupping and curling, as well as foliar chlorosis and necrosis in immature leaves and growing points.

An arcsin transformation of percent weed control data was made and the resulting data were analyzed by PROC GLM of SAS to determine any differences among treatments or interactions. Mean separation by LSD was determined from the transformed data but the original data are presented in the tables for ease of understanding the level of weed control obtained.

## RESULTS AND DISCUSSION

The spring and summer of 2007 were an unusual growing season, due to an April freeze (-5 to -1°C), a lack of precipitation for the majority of the summer months and above average temperatures. From May 1st 2007 until September 30th, 2007, Spindletop Research Farm received a total of 351 mm of precipitation, which is below the normal precipitation by 163 mm. Over this same period, the temperature averaged 3°C above normal. Monthly precipitation accumulations and average temperatures for the months of May 2007 through September 2008 are presented in Appendix I.

**Six Selective Rope Wick Treatments.** Canada thistle populations were dense throughout the experimental area, making visual control ratings of the top growth easy to obtain for both years. The high densities are common for Canada thistle due to vegetative propagation with a spreading root system, once seedlings have established (Donald, 1994).

The statistical analyses revealed a year by treatment interaction two weeks after treatment. All other year by treatment interactions were insignificant (Table 2.2). Since only the 2 WAT was significant, the data were dropped from future discussion. The early evaluations were to determine the length of time for herbicide symptomology to occur. The treatment of aminopyralid at 1% v/v provided highly variable control from 2007 to 2008 the same was true for triclopyr at 20% v/v (Table 2.4).

The year factor was significant at 0.05 level for two, and four weeks after treatments. Treatments were significant at 0.05 level for all visual percent control sampling dates (Table 2.2).

Aminopyralid at 20% v/v provided the greatest Canada thistle control throughout all evaluations. However, one week after treatment there was no statistical differences between treatments for herbicide symptomology. Canada thistle control from aminoypralid at 10% v/v, glyphosate at 50% v/v were not different from aminopyralid at 20%v/v, 1, 3, 4 and 8 weeks after application and all had greater than 80% control of Canada thistle. Clopyralid at 20% v/v was not statistically different from aminopyralid at 10 and 20% v/v or glyphosate at 50% v/v 8 WAT with Canada thistle control ranging from 88 to 97% (Table 2.3).

Aminopyralid at 1% v/v and triclopyr at 20% v/v provided the lowest symptomology 1, 3, and 4 weeks after treatment, with less than 70% control. Eight weeks after treatment aminopyralid at 1% v/v controlled 81% of the Canada thistle, while triclopyr at 20% v/v controlled only 66% (Table 2.3)

At this time only one year after treatment data can be reported for the 2007 trial. Aminopyralid at 10 and 20% v/v had 25 and 23% control, respectively, 1 YAT and aminopyralid at 1%v/v had 15% control and was not different from any other treatment (Table 2.5). No statistical differences were detected between treatments 1 YAT (Table 2.5). Canada thistle plants treated with aminopyralid and glyphosate with a rope-wick exhibited similar injury symptoms 1, 3, and 4 WAT. However, control 1YAT was 25% or less (Table 2.5)

Canada thistle plants and roots were removed from all of the treatment areas 8 WAT to observe the status of the root system. Plants treated with aminopyralid at 10 and 20 % v/v had decaying roots and top growth, with no active signs of growth. Aminopyralid at 1% v/v produced plants with active top growth with green leaves that showed herbicide injury and a live and active root system. Plants from glyphosate at 50% v/v had decaying top growth but the root system appeared to be healthy and without decay. Triclopyr and clopyralid at 20%v/v resulted in Canada thistle injury and partial top growth decay; however, root systems appeared to be normal with active growth and no signs of decay.

**Comparative Broadcast and Rope-wick Treatments for 2008.** The statistical analysis revealed no statistical difference between aminopyralid broadcast treatment, aminopyralid 10% v/v, glyphosate 50% v/v, and clopyralid 20% v/v 1 WAT. Broadcast treatment had 71% symptoms 2 WAT and was a statistically lower percent symptom than aminopyralid 10 and 20 % v/v, with 88% and 98 % control, respectively. Aminopyralid 10 and 20% v/v revealed no statistical difference 3 WAT with 95 and 99% symptoms, respectively. Aminopyralid broadcast treatment differed statistically from the aminopyralid and glyphosate rope-wick treatments at 78% symptoms 3 WAT. Broadcast treatment showed 83% herbicide symptomology of Canada thistle and was not statistically different to clopyralid and glyphosate treatments 4 WAT. Aminopyralid 1, 10 and 20% v/v and clopyralid treatments were statistically similar with control ranging from 91 to 97 % control 8 WAT. Aminopyralid applied broadcast was statistically equal to aminopyralid 1% v/v, glyphosate, and clopyralid, with control ranging from 82 to 95%.

This comparison showed that the rope-wick applicator can deliver an even distribution of herbicide and control was equal to the broadcast application through the 8 weeks following application. However, 1 YAT data may reveal different results between broadcast treatments and rope-wick treatments. Therefore, conclusions on which method would better control or suppress Canada thistle should not be drawn until the data one year after treatment is collected and analyzed.

**Table 2. 1: Rope-wick and broadcast treatments, rate and concentration evaluated for Canada thistle control in 2007 and 2008 near Lexington, KY.**

| Brand Name[1] | Treatment | Concentration/ Rate | Acid Equivalent | Application Method |
|---|---|---|---|---|
| Milestone | Aminopyralid | 1% v/v | 0.24 kg/L | Rope-wick |
| Milestone | Aminopyralid | 10% v/v | 0.24 kg/L | Rope-wick |
| Milestone | Aminopyralid | 20% v/v | 0.24 kg/L | Rope-wick |
| Roundup WeatherMax | Glyphosate | 50% v/v | 0.66 kg/L | Rope-wick |
| Remedy Ultra | Triclopyr | 20% v/v | 0.48 kg/L | Rope-wick |
| Stinger | Clopyralid | 20% v/v | 0.36 kg/L | Rope-wick |
| Milestone | Aminopyralid[2] | 70 g a.e./ha | 0.24 kg/L | Broadcast |

1. Milestone, Remedy Ultra, Stinger manufactured by Dow AgroSciences, Roundup WeatherMax manufactured by Monsanto.
2. Treatment was only applied in 2008

**Table 2. 2: Probability of a greater F for year, treatment, and treatment by year interaction as determined by PROC GLM in SAS.**

| | | Weeks After Treatment | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 8 |
| **Source** | **Degrees of Freedom** | **Pr > F** | | | | |
| **Year** | 1 | 0.1067 | 0.0637 | 0.4351 | 0.0210 | 0.1280 |
| **Treatment** | 6 | 0.0001 | <.0001 | <.0001 | <.0001 | 0.0014 |
| **Year * Treatment** | 5 | 0.2960 | 0.0257 | 0.3058 | 0.6306 | 0.2386 |

**Table 2. 3: Canada thistle control with rope-wick treatments in 2007 and 2008 near Lexington, KY. Data were averaged across years.**

| | | Percent Control WAT | | | |
|---|---|---|---|---|---|
| **Treatments** | **Concentration** | **1** | **3** | **4** | **8** |
| **Aminopyralid** | 1% v/v | 64 a | 64 cb | 70 c | 81 bc |
| **Aminopyralid** | 10% v/v | 82 a | 92 ab | 95 ab | 94 ab |
| **Aminopyralid** | 20% v/v | 89 a | 96 a | 96 a | 97 a |
| **Glyphosate** | 50% v/v | 86 a | 90 ab | 94 ab | 89 ab |
| **Triclopyr** | 20% v/v | 63 a | 60 c | 62 c | 66 c |
| **Clopyralid** | 20% v/v | 81 a | 81 bc | 85 cb | 88 abc |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$.

**Table 2. 4: Canada thistle control 2 weeks after treatment where a year by treatment interaction occurred.**

| | | Percent Control | |
|---|---|---|---|
| **Treatments** | **Concentration** | **2007** | **2008** |
| Aminopyralid | 1% v/v | 73 c | 45 d |
| Aminopyralid | 10% v/v | 86 ab | 88 b |
| Aminopyralid | 20% v/v | 91 a | 98 a |
| Glyphosate | 50% v/v | 89 ab | 90 ab |
| Triclopyr | 20% v/v | 74 c | 49 d |
| Clopyralid | 20% v/v | 83 b | 78 c |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$.

**Table 2. 5: Canada thistle control 1 YAT near Lexington, KY in 2007.**

| | | Percent Control |
|---|---|---|
| **Treatments** | **Concentration** | **1 YAT** |
| Aminopyralid | 1% v/v | 15 a |
| Aminopyralid | 10% v/v | 25 a |
| Aminopyralid | 20% v/v | 23 a |
| Glyphosate | 50% v/v | 0 a |
| Triclopyr | 20% v/v | 0 a |
| Clopyralid | 20% v/v | 8 a |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$.

**Table 2. 6: Canada thistle control with rope-wick treatments and broadcast treatment in 2008 near Lexington, KY.**

| | | Percent Control (WAT) | | | | |
|---|---|---|---|---|---|---|
| Treatments | Concentration/ Rate | 1 | 2 | 3 | 4 | 8 |
| Aminopyralid | 1% v/v | 56 c | 45 d | 56 f | 74 c | 91 ab |
| Aminopyralid | 10% v/v | 81 ab | 88 b | 95 ab | 97 a | 97 a |
| Aminopyralid | 20% v/v | 91 a | 98 a | 99 a | 98 a | 97 a |
| Glyphosate | 50% v/v | 87 ab | 90 ab | 90 bc | 94 ab | 82 bc |
| Triclopyr | 20% v/v | 51 c | 49 d | 65 ef | 70 c | 76 c |
| Clopyralid | 20% v/v | 79 ab | 78 bc | 85 cd | 94 ab | 95 ab |
| Aminopyralid | 70 g a.e. /ha | 76 b | 71 c | 78 ed | 83 bc | 84 bc |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$.

# CHAPTER 3: TALL IRONWEED CONTROL: COMPARISON OF ROPE-WICK AND BROADCAST TREATMENTS

## INTRODUCTION

Tall Ironweed (*Vernonia altissima*) is a perennial dicotyledon that is native to the United States (U.S. Department of Agriculture Agricultural Research Service 1970). In Kentucky it is commonly found in over-grazed pastures, wet bottoms and upland sites (Marshall, 2006b). A 2007 survey of Kentucky Agriculture Extension Agents ranked tall ironweed as the number one most problematic weed in Kentucky pastures (Green 2007, unpublished data).

Tall ironweed ranges in size of 1 to 3 m tall, with leaves alternating along the stem. Leaves are lanceolate and 15 to 25 cm in length and 3 to 7 cm in width (Gleason and Cronquest, 1963). Tall ironweed flowers from August through September in Kentucky, producing reddish-purple flowers arranged in an open inflorescence that can be flattened, concave, or irregular with 15 to 30 florets (Gleason, 1952). Tall ironweed reproduces by seeds and vegetative buds of the root crown (Mann et al., 1983).

Current herbicide control for tall ironweed in the University of Kentucky Cooperative Extension Service AGR-172 lists metsulfuron, dicamba plus 2,4-D and glyphosate as a suppression or partial control and lists aminopyralid, aminoplyralid plus 2,4-D, triclopyr, fluroxypyr, triclopyr plus 2,4-D, and triclopyr plus fluroxypyr as having excellent or good control (Green et al., 2006). Other recommendations for control of tall ironweed are mowing in mid summer with herbicide treatment following in late summer to early fall (Marshall, 2006a).

Peters and Lowance (1979) reported inconsistent control of tall ironweed with 2, 4-D and glyphosate treatments over three years of results. They further reported that picloram showed consistent tall ironweed control (Peters and Lowance, 1979). McCarty and Linscott (1962) reported that 1 lb/A of 2,4-D repeated over several years in early to mid summer gave excellent control of Baldwin's ironweed (*Veronia baldwinii*, Torr.). Triclopyr had the greatest regrowth inhibition, while 2,4-D ester had acceptable inhibitions of tall ironweed growth in a greenhouse study (Mann et al., 1983). They further reported that treatments of fosamine, dicamba, 2,4-D (alkanolamine) and 3,6-dichloropicolinic did not inhibit regrowth of basal buds the year after treatment (Mann et al., 1983). Marshall et al. (2006b) reported 93 to 99% tall ironweed control 8 MAT and 84 to 94% control 12 MAT with treatments containing triclopyr, and less than 60% control 12 MAT for dicamba.

A rope-wick applicator can be utilized to eliminate or reduce injury to desirable grasses and legumes since the herbicide touches only upright weed species such as tall ironweed, this technique provides a selective method of control. Currently, University of Kentucky has no recommendations for the use of rope-wick treatments on perennial dicot weeds in pastures. Furthermore, there has been no research reported on rope-wick applications for tall ironweed control in pastures. Currently, you can find published research on rope-wick applicators or other wiping technology on Canada thistle (*Cirsium arvense*) (Grekul et al. 2005; Krueger-Mangold et al. 2002; Boerboom and Wyse 1988), leafy spurge (*Euphorbia esula*) (Regimabal and Martin 1981; Moonaw and Martin 1990), Larkspurs (*Delphinium spp.)* (Ralphs et al. 1991), cogongrass (*Imperata cylindrica*) (Willard et al. 1997), giant burreed (*Sparaganium eurycarpum*) (Leif and Oelke 1990). The above studies reported that higher herbicide concentrations were needed to achieve acceptable levels of control with rope-wick treatments (Willard et al. 1997; Leif and

Oelke 1990) and that wiping at least two times increased control (Willard et al. 1997; Boerboom and Wyse, 1988; Moomaw and Martin 1990). Ralphs et al. (1991) reported similar control of larkspur with spot-spray and wiping treatments. Moomaw and Martin (1990) found significant differences of control between broadcast and rope-wick treatments with picloram.

The objectives of this study were to (1) evaluate the utility of rope-wick for applying herbicides to tall ironweed, and (2) evaluate herbicides for use in rope-wick applicators.

## MATERIAL AND METHODS

An experiment was conducted to evaluate the response of tall ironweed to pasture herbicides utilizing rope-wick application. The experiments were conducted in June 2007 and 2008 in pastures in Fayette (location one) and Boone Counties (location two).

### Location One

Two experiments were conducted in June of 2007 and 2008 in southeast Fayette County, Kentucky. The site consisted of a permanent grass pasture that is continuously grazed during the year. The pasture consisted of a mixture of tall fescue, Kentucky bluegrass and white clover with a heavy infestation of tall ironweed, as well as horsenettle (*Solanum carolinense*) and spiny amaranthus (*Amaranthus spinosus*).

The experimental designs were randomized complete blocks with four replications. Individual plot size was 3 meter by 30 meter.

Treatments were: aminopyralid, 2,4-D, triclopyr, clopyralid, and glyphosate used alone or in combination (Table 3.1). A nonionic surfactant was added to broadcast treatment mixtures at 0.25% v/v. Herbicides were applied when the tall ironweed reached a height of at least 45 cm. The broadcast application was applied at 168 L/ha using an ATV carbon dioxide pressurized sprayer with flat fan nozzles at a pressure of 275 kPa with a 3 m spray boom. Rope-wick selective treatments were applied using an ATV with a front mounted, height adjustable rope-wick that was 1.5 meter in length. Rope-wick selective treatments were applied on a volume by volume basis with the rope-wick bar being set at a height of 20 cm above the ground.

Plots were evaluated for herbicide symptomology 1, 2, 3, and 4 weeks after treatment and 8 and 52 weeks after treatments for percent visual control. Herbicide symptomology evaluated was bending and twisting of stems and petioles, swelling and elongation of stems, and leaf cupping and curling, as well as foliar chlorosis and necrosis in immature leaves and growing points. Initial tall ironweed population in each plot was determined by full plot population counts before treatments were applied and one year after treatment.

An arcsin transformation of percent weed control data was made and the resulting data were analyzed by PROC GLM of SAS to determine any differences among treatments or interactions. Square root transformation of tall ironweed counts was made and the resulting data were analyzed by PROC GLM of SAS. Mean separation by Fisher's LSD (p=.05) was determined from the transformed data but the original data are presented in the tables for ease of understanding the level of weed control obtained.

**Location Two**

Two trials were conducted in late June of 2007 and early July 2008 in Boone County, Kentucky. Sites were permanent grass pastures continuously grazed from spring through fall. The site consisted of a permanent stand of tall fescue and Kentucky bluegrass, with a small population of white clover. Tall ironweed was the dominant weed, and all other weeds were grazed along with the desirable forage.

The experimental design was a randomized complete block with four replications in the 2007 trial and three replications in the 2008 trial. The 2008 trial contained three replications due to available pasture area. Plot size was 3 m by 12 m.

Treatments were: aminopyralid, 2,4-D, triclopyr, clopyralid, and glyphosate used alone or in combination (Table 3.1). A nonionic surfactant was added to broadcast treatment mixtures at 0.25% v/v. Herbicides were applied when the tall ironweed reached a height of at least 45 cm. The broadcast treatment was applied at 168 L/ha using an ATV carbon dioxide pressurized sprayer with a 3 m spray boom. Rope-wick selective treatments were applied using an ATV with a front mounted, height adjustable rope-wick that was 1.5 meter in length. Rope-wick selective treatments were applied on a volume by volume basis with the rope-wick bar being set at a height of 20 cm above the ground.

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## RESULTS AND DISCUSSION

The growing season for the spring and summer of 2007 was challenged by an April freeze (-5 to -1°C) that lasted six days and a severe drought that impacted a large portion of Kentucky for the summer. Average temperatures for 2007 at Fayette and Boone County locations were above normal by 1.1 to 3.6°C for the months of June and August (Appendix II and III). July air temperatures were slightly below normal by 0.5°C. Precipitation for both locations was below normal the summer of 2007, however, the Boone County location received the least amount of rainfall and was in a severe drought from July through September. The Fayette County location received more precipitation in July but was still considered in a moderate drought. Monthly precipitation accumulations and average air temperatures for the months of June 2007 through September 2008 are presented in Appendix II and III.

The statistical analysis of visual percent control data revealed a location by treatment interaction at all sampling dates (Table 3.2). A year by location by treatment interaction was revealed 1, 3, and 4 WAT. No interaction was revealed 2 and 8 WAT for year by location by treatment. The location by treatment interactions could be due to the differences in climate data for 2007 growing season, where Fayette County received twice the amount of rain after treatments were applied compared to Boone County (Appendix II and III). Treatments were significant at all sampling dates, but the year effect was significant 1, 2, 3, and 4 WAT. Location was insignificant 1, 2, 3, and 4 WAT, but was significant 8 WAT (Table 3.2).

**Tall Ironweed Control.** Sampling dates for percent control taken 1, 2, 3, and 4 WAT were rated for herbicide damage and symptomology to tall ironweed. Therefore, all treatments showed herbicide damage and symptomology to tall ironweed 1, 2, 3 and 4 WAT. Data for 1 WAT will not be discussed; however, data for 2 and 8 WAT will be averaged across year and location, while 3 and 4 WAT data will be shown individually.

The 10 and 20% v/v of aminopyralid treatments and glyphosate exhibited the greatest level of damage 2 WAT and were not statistically different from one another with 93 to 95% symptoms (Table 3.3). The other treatments were statistically different from the aforementioned treatments, but statistically similar to each other 2 WAT, except for the untreated check. At 8 WAT, the broadcast treatment of aminopyralid + 2,4-D had 96% control of tall ironweed was not statistically different from the rope-wick treatment of aminopyralid at 20% v/v with 97% control. Aminopyralid at 1% v/v provided less control than the other aminopyralid treatments 8 WAT with 82% control and did not differ statistically from triclopyr or clopyralid (Table 3.3).

The year by location by treatment interaction that occurred 3 and 4 WAT revealed similar results for both years and both locations. Aminopyralid at 20% v/v revealed the highest level of control for Fayette County location for both 2007 and 2008, with 99 and 96% symptoms, respectively, and were statistically different from all other treatments 3 WAT. The Boone County location revealed glyphosate at 50% v/v had the highest level of herbicide symptoms in 2007 and 2008 with 98 and 95%; however, in 2008 glyphosate was not statistically different from aminopyralid at 20% v/v 3 WAT (Table 3.4). The interaction 4 WAT revealed that aminopyralid at 20% v/v had the highest level of herbicide symptoms at Fayette County in both 2007 and 2008; however it was not statistically different to aminopyralid at 10% v/v in 2008 with 96% symptoms. The Boone County location revealed no difference between aminopyralid at 20% v/v and glyphosate in 2007 with 96% herbicide symptoms. In 2008 at Boone County, there was no statistical difference between aminopyralid plus 2,4-D, aminopyralid at 20% v/v and glyphosate with 90% herbicide symptomology. All other treatments 4 WAT in 2008 for Boone County were statistically different from the aforementioned treatments (Table 3.5).

The broadcast treatment of aminopyralid + 2,4-D controlled 87% of tall ironweed 1 YAT, and was greater compared to the rope-wick treatments (Table 3.6). Aminopyralid at 20% v/v controlled 66% of the tall ironweed and was statistically greater than the other rope-wick treatments. Aminopyralid at 1 and 10% v/v and glyphosate controlled 28, 36 and 34% of tall ironweed, respectively, 1 YAT and were not statistically different from one another. Triclopyr and clopyralid controlled the least amount of tall ironweed with only 23% control (Table 3.6). Mann et al. (1983) and Marshall et al. (2006) reported that broadcast treatments containing triclopyr provided greater than 90% tall ironweed control. However, triclopyr at 20% v/v as a rope-wick treatment controlled 23% of tall ironweed 1 YAT.

**Tall Ironweed Population.** Tall ironweed populations were reduced 1 YAT and was consistent with the visual percent control data, this is shown by the significant correlation in Table 3.6. Aminopyralid + 2,4-D reduced the tall ironweed population by 83% 1 YAT (Table 3.5). McCarty and Linscott (1962) reported 2,4-D provided the greatest control of western ironweed stand with early summer treatments made for five consecutive years. The highest stand reduction with rope-wick application was 64% with aminopyralid 20% v/v (Table 3.5). The two lowest rates of aminopyralid and glyphosate decreased tall ironweed population 21 to 29%. Triclopyr and clopyralid treatments reduced the population stands by 2 and 3 %, respectively (Table 3.5). Mann et al. (1983) and Marshall et al. (2006b) reported greater than 90% control with triclopyr containing treatments using broadcast application methods. Furthermore, timing of application, summer versus fall could have affected the control tricloypr and clopyralid had on tall ironweed. Past research with dicamba and 2,4-D reported that above ground biomass was controlled in the treatment year, but did not suppress shoot growth the following year (Mann et al. 1983). Pearson correlation coefficient analysis showed a significant correlation between 1 YAT visual percent control data and tall ironweed populations 1 YAT. Correlations between percent reduction 1 YAT and 8 WAT were also significant (Table 3.6).

In summary, the objectives of this study were evaluated and the utility of rope-wick for applying herbicides to tall ironweed provided control. However, further research should be conducted to evaluate control measures with more than one pass over tall ironweed. Experiments conducted on Canada thistle (Boerboom and Wyse 1988) and cogongrass (Willard et al. 1997) reported greater control with two passes of rope-wick or wiper compared to one pass. The evaluation of herbicides for use in rope-wick applicators determined that several herbicides were useful and provided sufficient control. However, triclopyr and clopyralid concentrations that were evaluated resulted in poor levels of extended control 1 YAT.

Rope-wick treatments in pastures with heavy infestations of tall ironweed cost considerably more than broadcast treatments which have greater control. Rope-wick treatments can be utilized effectively in an IPM program as a spot treatment in pasture with low populations of tall ironweed.  A decision of when tall ironweed thresholds decrease forage yield will determine which application method would better serve to reduce tall ironweed populations.  Tall ironweed population should be a determining factor in whether or not to utilize rope-wick or broadcast treatments.

**Table 3. 1: Rope-wick and broadcast treatments, rate and concentrations evaluated for tall ironweed (*Vernonia altissima*) control in 2007 and 2008 in Boone and Fayette Counties, Kentucky.**

| Product Name[1] | Treatment | Acid Equivalent | Amount per Hectare or Concentration | Application Method |
|---|---|---|---|---|
| ForeFront R&P | Aminopyralid + 2,4-D | 0.04 + 0.32 kg/L | 93 + 800 g a.e./ha | Broadcast |
| Milestone | Aminopyralid | 0.24 kg/L | 1% v/v | Rope-wick |
| Milestone | Aminopyralid | 0.24 kg/L | 10% v/v | Rope-wick |
| Milestone | Aminopyralid | 0.24 kg/L | 20% v/v | Rope-wick |
| Roundup Weather Max | Glyphosate | 0.66 kg/L | 50% v/v | Rope-wick |
| Stinger | Triclopyr | 0.36 kg/L | 20% v/v | Rope-wick |
| Remedy Ultra | Clopyralid | 0.48 kg/L | 20% v/v | Rope-wick |
| | Untreated | | | |

1. ForeFront R&P, Milestone, Stinger, Remedy Ultra manufactured by Dow AgroSciences, and Roundup WeatherMax manufactured my Monsanto.

**Table 3. 2: Probability of a greater F for year, location, treatment and year x treatment, location x treatment, and year x location x treatment interaction as determined from PROC GLM in SAS.**

| | | Weeks After Treatments | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 8 |
| Source | DF | Pr > F | | | | |
| Year | 1 | <.0001 | 0.0001 | <.0001 | 0.0162 | 0.9018 |
| Location | 1 | 0.7406 | 0.0535 | 0.5287 | 0.4721 | 0.0354 |
| Treatment | 7 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| Year x Treatment | 7 | <.0001 | 0.1040 | 0.4488 | 0.9710 | 0.4513 |
| Location x Treatment | 7 | 0.0001 | 0.0119 | 0.0125 | 0.0047 | 0.0336 |
| Year x Location x Treatment | 8 | 0.0031 | 0.1281 | 0.0136 | 0.0085 | 0.0801 |

**Table 3. 3: Tall ironweed (*Vernonia altissima*) control with broadcast and rope-wick treatments in 2007 and 2008 in Fayette and Boone Counties, Kentucky. Data were averaged across year and location.**

| | | **Visual Percent Control (WAT)** | |
|---|---|---|---|
| **Treatments** | **Rate or Concentration** | **2** | **8** |
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 87 b | 96 a |
| **Aminopyralid** | 1% v/v | 88 b | 82 cd |
| **Aminopyralid** | 10% v/v | 93 a | 89 b |
| **Aminopyralid** | 20% v/v | 95 a | 97 a |
| **Glyphosate** | 50% v/v | 95 a | 87 bc |
| **Triclopyr** | 20% v/v | 89 b | 83 cd |
| **Clopyralid** | 20% v/v | 85 b | 79 d |
| **Untreated Check** | | 3 c | 0 e |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$.

**Table 3.4: Tall Ironweed (*Vernonia altissima*) visual percent control for Fayette and Boone Counties where a year by location by treatment interaction occurred 3 WAT.**

| | | Fayette | | Boone | |
|---|---|---|---|---|---|
| Treatments | Rate/ Concentration | 2007 | 2008 | 2007 | 2008 |
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 94 bc | 73 d | 90 c | 92 b |
| **Aminopyralid** | 1% v/v | 93 c | 78 d | 86 c | 85 c |
| **Aminopyralid** | 10% v/v | 94 bc | 93 b | 90 c | 83 cd |
| **Aminopyralid** | 20% v/v | 99 a | 96 a | 94 b | 93 ab |
| **Glyphosate** | 50% v/v | 96 b | 89 c | 98 a | 95 a |
| **Triclopyr** | 20% v/v | 85 d | 85 c | 81 d | 82 cd |
| **Clopyralid** | 20% v/v | 84 d | 76 d | 86 c | 78d |
| **Untreated Check** | | 8 e | 0 e | 0 e | 0 e |

**Table 3.5: Tall Ironweed (*Vernonia altissima*) visual percent control for Fayette and Boone Counties where a year by location by treatment interaction occurred 4 WAT.**

| | | Fayette | | Boone | |
|---|---|---|---|---|---|
| **Treatments** | **Rate/ Concentration** | **2007** | **2008** | **2007** | **2008** |
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 86 c | 80 e | 90 b | 90 a |
| **Aminopyralid** | 1% v/v | 89 cb | 84 de | 83 d | 82 b |
| **Aminopyralid** | 10% v/v | 92 b | 96 a | 89 bc | 80 bc |
| **Aminopyralid** | 20% v/v | 97 a | 96 a | 96 a | 90 a |
| **Glyphosate** | 50% v/v | 93 b | 90 bc | 96 a | 90 a |
| **Triclopyr** | 20% v/v | 76 d | 86 cd | 91 b | 75 c |
| **Clopyralid** | 20% v/v | 75 d | 79 e | 85 cd | 78 c |
| **Untreated Check** | | 8 e | 0 f | 0 e | 0 d |

**Table 3. 6: Tall ironweed control with broadcast and rope-wick treatments for 1 YAT in Fayette and Boone Counties, Kentucky. Data were averaged across location.**

| Treatments | Rate/ Concentration | 1 YAT |
|---|---|---|
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 87 a |
| **Aminopyralid** | 1% v/v | 28 c |
| **Aminopyralid** | 10% v/v | 36 c |
| **Aminopyralid** | 20% v/v | 66 b |
| **Glyphosate** | 50% v/v | 34 c |
| **Triclopyr** | 20% v/v | 23 d |
| **Clopyralid** | 20% v/v | 23 d |
| **Untreated Check** | | 5 e |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$.

**Table 3.7: Tall ironweed (*Vernonia altissima*) initial and 1 YAT populations and percent reduction of population for 2007 at Fayette and Boone Counties, Kentucky.**

| Treatments | Rate or Concentration | Population (10 sq. m) | | Percent Reduction |
|---|---|---|---|---|
| | | Initial | 1 YAT | |
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 3.22 | 0.56 | 83 |
| **Aminopyralid** | 1% v/v | 4.18 | 3.28 | 21 |
| **Aminopyralid** | 10% v/v | 2.57 | 1.83 | 29 |
| **Aminopyralid** | 20% v/v | 1.99 | 0.71 | 64 |
| **Glyphosate** | 50% v/v | 1.89 | 1.42 | 25 |
| **Triclopyr** | 20% v/v | 1.78 | 1.74 | 2 |
| **Clopyralid** | 20% v/v | 2.37 | 2.3 | 3 |
| **Untreated Check** | | 2.95 | 3.93 | -33 |

**Table 3.8: Correlation of visual percent control data for 1 YAT (2007), 8 WAT (2007 and 2008), and percent reduction of population for 2007.**

| | 1 YAT | 8 WAT | Percent Reduction |
|---|---|---|---|
| **1 YAT** | 1 | 0.91086<br>0.0043 | 0.9849<br><.0001 |
| **8 WAT** | 0.91086<br>0.0043 | 1 | 0.93297<br>0.0022 |
| **Percent Reduction** | 0.9849<br><.0001 | 0.93297<br>0.0022 | 1 |

## CHAPTER 4: COMPARISON OF ROPE-WICK TREATMENTS TO STANDARD BROADCAST TREATMENT RECOMMENDATION FOR TALL IRONWEED CONTROL

### INTRODUCTION

Tall Ironweed (*Vernonia altissima*) is a perennial dicotyledon that is native to the United States (U.S. Department of Agriculture Agricultural Research Service 1970). In Kentucky it is commonly found in over-grazed pastures, wet bottoms and upland sites (Marshall, 2006b). A 2007 survey of Kentucky Agriculture Extension Agents ranked tall ironweed as the number one most problematic weed in Kentucky pastures (Green 2007).

Tall ironweed ranges in size of 1 to 3 m tall, with leaves alternating along the stem. Leaves are lanceolate and 15 to 25 cm in length and 3 to 7 cm in width (Gleason and Cronquest, 1963). Tall ironweed flowers from August through September in Kentucky, producing reddish-purple flowers arranged in an open inflorescence that can be flattened, concave, or irregular with 15 to 30 florets (Gleason, 1952). Tall ironweed reproduces by seeds and vegetative buds of the root crown (Mann et al., 1983).

Current herbicide options for tall ironweed in the University of Kentucky Cooperative Extension Service AGR-172 lists metsulfuron, dicamba plus 2,4-D and glyphosate as a suppression or partial control measure and lists aminopyralid, aminopyralid plus 2,4-D, triclopyr, fluroxypyr, triclopyr plus 2,4-D, and triclopyr plus fluroxypyr as having excellent or good control (Green et al., 2006). Other recommendations for control of tall ironweed are mowing in mid summer with an herbicide treatment following in late summer to early fall (Marshall, 2006a).

Peters and Lowance (1979) reported inconsistent control of tall ironweed with 2, 4-D and glyphosate treatments over three years of results. They further reported that picloram showed consistent tall ironweed control (Peters and Lowance, 1979). McCarty and Linscott (1962) reported that 1 lb/A of 2,4-D repeated over several years in early to mid summer gave excellent control of Baldwin's ironweed (*Veronia baldwinii*, Torr.). Triclopyr had the greatest regrowth inhibition, while 2,4-D ester had acceptable inhibition of tall ironweed growth in a greenhouse study (Mann et al., 1983). They further reported that treatments of fosamine, dicamba, 2,4-D (alkanolamine) and 3,6-dichloropicolinic did not inhibit regrowth of basal buds the year after treatment (Mann et al., 1983). Marshall et al. (2006b) reported 93 to 99% tall ironweed control 8 MAT and 84 to 94% control 12 MAT with treatments containing triclopyr, and less than 60% control 12 MAT for dicamba.

A rope-wick applicator can be utilized to eliminate or reduce injury to desirable grasses and legumes since the herbicide touches only upright weed species such as tall ironweed, this technique provides a selective method of control. Currently, University of Kentucky has no recommendations for the use of rope-wick treatments on perennial dicot weeds in pastures. Furthermore, there has been no research reported on rope-wick applications for tall ironweed control in pastures. Currently, you can find published research on rope-wick applicators or other wiping technology on Canada thistle (*Cirsium arvense*) (Grekul et al. 2005; Krueger-Mangold et al. 2002; Boerboom and Wyse 1988), leafy spurge (*Euphorbia esula*) (Regimabal and Martin 1981; Moonaw and Martin 1990), Larkspurs (*Delphinium spp.)* (Ralphs et al. 1991), cogongrass (*Imperata cylindrica*) (Willard et al. 1997), giant burweed (*Sparaganium eurycarpum*) (Leif and Oelke 1990). The above studies reported that higher concentrations of herbicide was needed to achieve acceptable levels of control with rope-wick treatments (Willard et al. 1997; Leif and Oelke 1990) and that wiping at least two times increased control (Willard et al. 1997; Boerboom and Wyse, 1988;

Moomaw and Martin 1990). Ralphs et al. (1991) reported similar control of larkspur with spot-spray and wiping treatments. Moomaw and Martin (1990) found significant differences of control between broadcast and rope-wick treatments with picloram.

The objectives of this study were to (1) evaluate the utility of rope-wick for applying herbicides to tall ironweed, (2) evaluate herbicides for use in rope-wick applicators, and (3) compare rope-wick treatments to current broadcast treatment recommendations.

## MATERIAL AND METHODS

Two experiments were conducted in late June of 2007 and early July 2008 in Boone County, Kentucky. The site consisted of a permanent stand of tall fescue and Kentucky bluegrass, with a small population of white clover. Pastures were grazed continuously from spring through fall. Tall ironweed was the dominant weed species, and all other weeds were grazed along with the desirable forage.

The experimental design each year was a randomized complete block with four replications in 2007. Three replications were used in the 2008 experiment due to available pasture area. Blocks consisted of twelve treatments and one control. Plot size consisted of a 3 m by 12 m area.

Treatments were: aminopyralid, 2,4-D triclopyr, fluroxypyr, triclopyr, glyphosate, clopyralid used alone of in combination (Table 4.1). All rates of broadcast treatments and concentration of rope-wick treatments are listed in Table 4.1. A nonionic surfactant was added to broadcast treatment mixtures at 0.25% v/v. Herbicides were applied when the tall ironweed reached a height of at least 45 cm. The broadcast treatments were applied at 168 L/ha using an ATV-mounted carbon dioxide pressurized sprayer with flat fan nozzles and a pressure of 275 kPa with a 3 m spray boom. Rope-wick selective treatments were applied using an ATV with a front mounted, height-adjustable 1.5 m rope-wick. Rope-wick selective treatments were applied on a volume by volume basis with the rope-wick bar being set at 20 cm above the ground.

Plots were evaluated for herbicide symptomology 1, 2, 3, and 4 weeks after treatment and 8 and 52 weeks after treatments for percent visual control. Herbicide symptomology evaluated was bending and twisting of stems and petioles, swelling and elongation of stems, and leaf cupping and curling, as well as foliar chlorosis and necrosis in immature leaves and growing points. Initial tall ironweed population in each plot was determined by full plot population counts before treatments were applied and one year after treatment.

An arcsin transformation of percent weed control data was made and the resulting data were analyzed by PROC GLM of SAS to determine any differences among treatments or interactions. Square root transformation of tall ironweed counts was made and the resulting data were analyzed by PROC GLM of SAS. Mean separation by Fisher's LSD (p=.05) was determined from the transformed data but the original data are presented in the tables for ease of understanding the level of weed control obtained.

## RESULTS AND DISCUSSION

The statistical analysis revealed a year by treatment interaction 1 week after treatments (Table 4.2). Ratings taken 1, 2, 3, and 4 WAT represent visual herbicide damage and symptomology, therefore, year by treatment interaction 1 WAT does not represent visual percent control. No other sampling dates resulted in a year by treatment interaction, therefore 1 WAT results will be dropped from further discussion. Treatment was significant 1, 2, 3, 4 and 8 WAT, and year was significant 1, 2, and 4 WAT, but not 3 and 8 WAT (Table 4.2).

**Tall Ironweed Control.** Sampling dates for percent control taken 2, 3 and 4 WAT were rated for herbicide damage and symptomology to tall ironweed and all treatments showed herbicide damage to tall ironweed at those times. Aminopyralid plus 2,4-D, and 2,4-D plus triclopyr applied broadcast, as well as the highest two concentrations of aminopyralid and glyphosate rope-wick treatments showed the highest level of symptoms 2 WAT (Table 4.3). Glyphosate 50% v/v showed the highest control with 97% 3 WAT. However, glyphosate did not differ statistically to aminopyralid 20% v/v, 2,4-D plus triclopyr, and aminopyralid plus 2,4-D, which ranged from 91 to 93% herbicide symptomology. The lowest level of symptoms 3 WAT was aminopyralid at 53 g a.e.per ha with 76%, however, this treatment did not differ statistically from aminopyralid 70 and 88 g a.e. per ha with 80 and 83% symptoms, respectively. Rope-wick treatments of triclopyr and clopyralid also did not differ statistically from aminopyralid applied broadcast with 80 to 83% symptoms, respectively 3 WAT. Aminopyralid plus 2,4-D, triclopyr plus fluroxypyr, and 2,4-D plus triclopyr applied broadcast showed 90% symptoms 4 WAT, and was statistically equal to aminopyralid 10 and 20% v/v with 93 and 97% symptoms, respectively (Table 4.3).

Percent visual control 8 WAT resulted in 97% control with the highest rope-wick concentration of aminopyralid and 96% and 95% control with aminopyralid plus 2,4-D, and 2,4-D plus triclopyr, and triclopyr plus fluroxypyr (Table 4.3). Additionally none of the aforementioned treatments differed statistically from one another. Glyphosate controlled 87% of the tall ironweeds and was statistically significant to the three broadcast treatments and aminopyralid at 10% v/v with 82% control. The lowest level of control obtained by a herbicide treatment 8 WAT was the lowest rates broadcast treatments of aminopyralid with 69 and 70% tall ironweed control; however, they did not differ statistically from aminopyralid at 1% v/v, and triclopyr and clopyralid at 20% v/v with control ranging from 74 to 80% (Table 4.3).

The broadcast treatment of aminopyralid plus 2,4-D provided 87% control of tall ironweed 1 year after treatment (YAT) in 2007; however, it did not differ statistically to broadcast treatments of triclopyr plus fluroxypyr, and 2,4-D plus triclopyr with 84 and 71% control. Rope-wick treatments of aminopyralid at 20% v/v and glyphosate at 50% v/v were also statistically similar with 63 and 50%, respectively (Table 4.4). The broadcast treatments of aminopyralid 70 and 88 g a.e. per ha had 10% control of tall ironweed 1 YAT; however the broadcast treatment of aminopyralid 53 g a.e. per ha controlled 34% of the tall ironweeds and was not statistically different from the aforementioned treatments. However, the rope-wick treatments of aminopyralid 1 and 10 %v/v, triclopyr, and clopyralid at 20% v/v were statistically the same with 11, 16, and 29% control of tall ironweed, respectively, 1YAT (Table 4.4).

**Tall Ironweed Population.** The greatest reduction of tall ironweed population was 81% 1YAT with a broadcast treatment of aminopyralid plus 2,4-D (Table 4.5). Other broadcast treatments of triclopyr plus fluroxypyr, and 2,4-D plus triclopyr had decreased populations of tall ironweed of 79 and 69%, respectively. Rope-wick applications did a poor job of decreasing tall ironweed plants, with aminopyralid 20% v/v only reducing population by 60%. Glyphosate 50% v/v only decreased tall ironweed plants by 37%. Broadcast aminopyralid had a reverse affect on tall ironweed population, by increasing tall ironweed population of 35 and 23% for 53 and 88 g a.e./ha, respectively (Table 4.5). One possible explanation for the increase population of tall ironweed with aminopyralid is lack of adequate precipitation, however, there should have been similar findings with rope-wick applications of aminopyralid. Furthermore, since the one year after data only represents the 2007 trial, there may be some clarification with the 2008 one year after treatment data to be collected in June of 2009.

Although there were increases in population as well as decreases in tall ironweed, a Pearson's Correlation Coefficient test resulted in a significant correlation between 1 YAT control data and population data, as well as a significant correlation between 8 WAT and population. Furthermore, there was significant correlation between 8 WAT and 1 YAT. The significance of the correlation analysis revealed that the visual percent control data accurately represented the tall ironweed population of the 2007 trial for 8 WAT and 1 YAT and the 2008 trial for 8WAT. The Pearson Correlation Coefficients Test is presented in Table 4.6.

The use of broadcast and rope-wick treatments in the experiment reduced tall ironweed population; however, broadcast treatments overall reduced 49% of the tall ironweed and were statistically different from all rope-wick treatments which reduced populations by 33% (Table 4.7).

In summary, the objectives of this study were evaluated and the utility of rope-wick for applying herbicides to tall ironweed provided control, however, further research should be conducted to evaluate control measures with more than one pass over tall ironweed. Experiments conducted on Canada thistle (Boerboom and Wyse 1988) and cogongrass (Willard et al. 1997) reported increase control with two passes of rope-wick or wiper versus just one pass. The evaluation of herbicides for use in rope-wick applicators determined that several herbicides were useful and provided control. However, triclopyr and clopyralid showed poor levels of extended control 1 YAT. Rope-wick treatments, when compared to broadcast treatments, provided less tall ironweed control under heavy tall ironweed populations. Rope-wick treatments can be utilized more effectively in an IPM program as a spot treatment in pasture with low populations of tall ironweed.  A decision of when tall ironweed thresholds decrease forage yield will determine which application method would better serve to reduce tall ironweed populations.  Tall ironweed population should be a determining factor in whether or not to utilize rope-wick or broadcast treatments.

**Table 4. 1: Rope-wick and broadcast treatments, rate and concentrations evaluated for Tall Ironweed (*Vernonia altissima*) control in 2007 and 2008 in Boone County, Kentucky.**

| Product Name[1] | Treatment | Acid Equivalent (kg/L) | Amount per Ha or Concentration | Application Method |
|---|---|---|---|---|
| Milestone | Aminopyralid | 0.24 | 53 g a.e./ha | Broadcast |
| Milestone | Aminopyralid | 0.24 | 70 g a.e./ha | Broadcast |
| Milestone | Aminopyralid | 0.24 | 88 g a.e./ha | Broadcast |
| ForeFront R&P | Aminopyralid + 2,4-D | 0.04 + 0.32 | 92 + 800 g a.e./ha | Broadcast |
| PastureGard | Triclopyr + fluroxpyr | 0.18 + 0.06 | 500 + 200 g a.e./ha | Broadcast |
| Crossbow | 2,4-D + triclopyr | 0.24 + 0.12 | 1100 + 600 g a.e./ha | Broadcast |
| Milestone | Aminopyralid | 0.24 | 1% v/v | Rope-wick |
| Milestone | Aminopyralid | 0.24 | 10% v/v | Rope-wick |
| Milestone | Aminopyralid | 0.24 | 20% v/v | Rope-wick |
| Roundup Weather Max | Glyphosate | 0.66 | 50% v/v | Rope-wick |
| Stinger | Triclopyr | 0.36 | 20% v/v | Rope-wick |
| Remedy Ultra | Clopyralid | 0.48 | 20% v/v | Rope-wick |

1. Milestone, ForeFront R&P, PastureGard, Crossbow, Stinger, and Remedy Ultra manufactured by Dow AgroSciences, and Roundup WeatherMax manufactured by Monsanto.

**Table 4. 2: Probability of a greater F for year, treatment and year x treatment interaction as determined from PROC GLM in SAS.**

| | | Weeks After Treatment | | | | |
|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **8** |
| **Source** | **DF** | **Pr>F** | | | | |
| **Year** | 1 | <.0001 | <.0001 | 0.6280 | 0.0036 | 0.1245 |
| **Treatment** | 12 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| **Year*Treatment** | 12 | 0.0018 | 0.1658 | 0.6198 | 0.5295 | 0.1188 |

**Table 4. 3: Tall ironweed control with broadcast and rope-wick application in 2007 and 2008 in Boone County, Kentucky. Data were averaged across years.**

| | | Percent Control (WAT) | | | |
|---|---|---|---|---|---|
| **Treatment** | **Rate or Concentration** | **2** | **3** | **4** | **8** |
| **Aminopyralid** | 53 g a.e./ha | 86d | 76f | 76e | 70d |
| **Aminopyralid** | 70 g a.e./ha | 89d | 80ef | 79de | 69d |
| **Aminopyralid** | 88 g a.e./ha | 91cd | 83def | 81de | 81cd |
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 93abc | 91bc | 90ab | 96ab |
| **Triclopyr + fluroxpyr** | 500 + 200 g a.e./ha | 89d | 90bc | 90ab | 95ab |
| **2,4-D + triclopyr** | 1100 + 600 g a.e./ha | 94ab | 93ab | 90ab | 96ab |
| **Aminopyralid** | 1% v/v | 91cd | 86cde | 82cde | 80cd |
| **Aminopyralid** | 10% v/v | 93abc | 87cd | 85bcd | 82c |
| **Aminopyralid** | 20% v/v | 93abc | 93ab | 93a | 97a |
| **Glyphosate** | 50% v/v | 97a | 97a | 93a | 87bc |
| **Triclopyr** | 20% v/v | 90bcd | 81def | 84bcd | 74cd |
| **Clopyralid** | 20% v/v | 89d | 83def | 82de | 79cd |
| **Untreated** | | 0e | 0g | 0f | 0e |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$.

**Table 4. 4: Tall ironweed visual percent control 1 YAT at Boone County, Kentucky for 2007.**

| Treatment | Rate or Concentration | Visual Percent Control 1 YAT |
|---|---|---|
| **Aminopyralid** | 53 g a.e./ha | 34 cd |
| **Aminopyralid** | 70 g a.e./ha | 10 de |
| **Aminopyralid** | 88 g a.e./ha | 10 de |
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 87 a |
| **Triclopyr + fluroxpyr** | 500 + 200 g a.e./ha | 84 a |
| **2,4-D + triclopyr** | 1100 + 600 g a.e./ha | 71 ab |
| **Aminopyralid** | 1% v/v | 11 c |
| **Aminopyralid** | 10% v/v | 16 c |
| **Aminopyralid** | 20% v/v | 63 b |
| **Glyphosate** | 50% v/v | 50 bc |
| **Triclopyr** | 20% v/v | 29 d |
| **Clopyralid** | 20% v/v | 29 d |
| **Untreated** | | 0 e |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05)}$

**Table 4. 5: Tall ironweed population initially before treatments, 1 YAT, and percent reduction of population in Boone County, Kentucky for 2007.**

| Treatment | Rate or Concentration | Population (10 sq. m) | | Percent Reduction |
|---|---|---|---|---|
| | | Initial | 1 YAT | |
| Aminopyralid | 53 g a.e./ha | 2.90 | 3.90 | -35 |
| Aminopyralid | 70 g a.e./ha | 2.76 | 2.63 | 5 |
| Aminopyralid | 88 g a.e./ha | 3.66 | 4.51 | -23 |
| Aminopyralid + 2,4-D | 92 + 800 g a.e./ha | 4.64 | 0.87 | 81 |
| Triclopyr + fluroxpyr | 500 + 200 g a.e./ha | 2.22 | 0.47 | 79 |
| 2,4-D + triclopyr | 1100 + 600 g a.e./ha | 3.03 | 0.94 | 69 |
| Aminopyralid | 1% v/v | 5.58 | 4.98 | 11 |
| Aminopyralid | 10% v/v | 3.23 | 2.83 | 13 |
| Aminopyralid | 20% v/v | 2.55 | 1.01 | 60 |
| Glyphosate | 50% v/v | 1.82 | 1.15 | 37 |
| Triclopyr | 20% v/v | 1.55 | 1.42 | 9 |
| Clopyralid | 20% v/v | 3.09 | 2.96 | 4 |
| Untreated | | 3.16 | 5.38 | -70 |

**Table 4. 6: Correlation coefficients for 1 YAT (2007), 8 WAT (2007 and 2008) and percent reduction of population (2007) for Boone County, KY.**

| | 52 WAT | 8 WAT | Percent Reduction |
|---|---|---|---|
| **52 WAT** | 1 | 0.81989 | 0.86983 |
| | | 0.0011 | 0.0002 |
| **8 WAT** | 0.81989 | 1 | 0.88742 |
| | 0.0011 | | 0.0001 |
| **Percent Reduction** | 0.86983<br>0.0002 | 0.88742<br>0.0001 | 1 |

**Table 4. 7: Tall ironweed percent visual control 1 YAT, average across application method for broadcast and rope-wick treatments in Boone County, Kentucky for 2007.**

| Application Method | Percent Visual Control |
|---|---|
| **Broadcast** | 49 a |
| **Rope-Wick** | 33 b |

* Mean with the same letter are not significantly different according to Fisher's Protected $LSD_{(.05}$

# CHAPTER 5: COST ESTIMATES ASSOCIATED WITH ROPE-WICK AND BROADCAST TREATMENTS

## INTRODUCTION

A survey of county extension agents conducted by J.D. Green (2007) reported that maintaining clover in pastures was the number one concern of producers and was the reason herbicides were not widely used for weed control in pastures. The second common reason for not using herbicides was expense. Green (2007) further found that approximately 15% of Kentucky pastures were treated with herbicides, while 61% of pastures were mowed one to two times per year. Beef producers with diverse forage species of grasses and legumes in pastures are limited to what type of weed control method they can utilize without damage to legumes. Labeled pasture herbicides applied as a foliar broadcast treatment usually kill or decrease desirable legumes in pastures. The use of a rope-wick applicator can be an effective method to control some tall, upright weeds and limits injury to legume species in pastures. However, rope-wick treatments need a higher concentration of herbicides in the total mixture because the applicator applies less herbicide to a smaller leaf surface area compared to broadcast treatments. The cost of weed control with a rope-wick is highly dependent on the number of weeds per unit area that are wiped. Therefore, more weeds in pastures will require a greater volume of an herbicide mixture compared to a pasture with fewer weeds. Therefore, the financial cost associated with the use of a rope-wick applicator may be higher than the cost associated with foliar broadcast treatments; however, are there might be other advantages to using one method over the other.

The objectives of this chapter were to (1) estimate the cost of rope-wick and foliar broadcast treatments on Canada thistle and tall ironweed, and (2) compare those methods with cost of mowing and reseeding of legumes.

## MATERIALS AND MEHTODS

Herbicides were applied when the tall ironweed reached a height of at least 45 cm and Canada thistle plants reached a height of at least 30 cm and were in the pre-bloom growth stage. The broadcast treatments were applied at 168 L/ha using an ATV-mounted carbon dioxide pressurized sprayer with flat fan nozzles and a pressure of 275 kPa with a 3 m spray boom. Rope-wick selective treatments were applied using an ATV with a front mounted, height-adjustable 1.5 m rope-wick. The rope-wick applicator held approximately 1.8 gallons of total mixture. Rope-wick selective treatments were applied on a volume by volume basis with the rope-wick bar being set at 20 cm above the ground. Treatments were: Milestone, ForeFront R&P, Roundup Weather Max, Remedy Ultra, Stinger, PastureGard, and Crossbow, used alone or in combination (Table 5.1).

Herbicide amount applied to Canada thistle with a rope-wick applicator was measured by having a known amount of herbicide in the rope-wick and then measuring the amount of herbicide after application to 1,600 $ft^2$. That amount was then converted to a gallon(s) per acre. Canada thistle infestations were considered high at 40,480 plants per acre. Tall ironweed infestations were considered moderate at 1,040 plants per acre.

## RESULTS AND DISCUSSION

The cost of herbicides for Canada thistle control in Table 5.1 is based on infestations of 10 plants per $m^2$. For Canada thistle densities at this level of infestation it takes approximately 5 gallons per acre of total herbicide solution to treat one side of the plants. The cost of Milestone is approximately $293 per gallon. On average the cost to treat one acre with a 1% volume/volume concentration of Milestone is $15.00 for 15% Canada thistle control (Table 5.1). Therefore, rates of 10 and 20% v/v are $150 and $300 per acre with 25 and 23% Canada thistle control, respectively. Treatments of Roundup Weather Max were based on $79 per gallon at 50% v/v concentration with a $198 per acre cost, and Canada thistle control was zero 1 YAT. Treatment costs of Remedy Ultra and Stinger at 20% v/v are $117 and $418 per acre with 0 and 8% Canada thistle control, respectively (Table 5.1). The Canada thistle control that is received with these levels of costs are insufficient with 8 to 25% control 1 YAT.

The cost of herbicides for tall ironweed control in Table 5.1 is based on infestations of 1,040 plants per acre and requires approximately 3 gallons per acre of total herbicide. The highest cost of herbicide associated with rope-wick treatments was Stinger at 20% v/v, with a cost of $250 per acre and provided 23 and 29% of tall ironweed at Fayette and Boone Counties, respectively (Table 5.1 and 5.2). The lowest cost of herbicide with rope-wick treatments was Milestone at 1 % v/v, with a cost of $9 per acre and provided 28 and 11% tall ironweed control. Mixtures of 10 and 20% v/v of Milestone cost $88 and $176 with 36 and 66% tall ironweed control, respectively. Roundup Weather Max at 50% v/v cost $119 per acre with 34 and 50% tall ironweed control. Remedy Ultra cost $70 per acre with 23 and 29% tall ironweed control. Broadcast applications of Milestone ranged in cost of $7 to $11 per acre and controlled 11 to 63% of tall ironweed (Table 5.2). ForeFront R&P cost $13 per acre with 87% tall ironweed control. The highest broadcast treatment was Crossbow with a cost of $29 per acre and 71% tall ironweed control (Table 5.2). Rope-wick treatments with high herbicide concentrations cost considerably more than did broadcast treatments.

When comparing broadcast and rope-wick treatments in Canada thistle or tall ironweed, the cost of mowing and reseeding of legume species to pasture should be considered to fully justify a management decision. The University of Kentucky Agriculture Economics Extension publication for Custom Machinery Rate Applicable to Kentucky (2008) states that the average cost of mowing is $13 per acre. The Forage Enterprise Budgets for University of Kentucky, Agriculture Economics publication (2006) list the cost to seed clover at $36 per acre and alfalfa at $80. Mowing provides no control of Canada thistle, and there is no published data on mowing to control tall ironweed. Mowing would only reduce above ground biomass and decrease possible seed dispersal if mowed early enough.

Considering all the above factors, producers need to consider what method or methods would better benefit there program and cost less time and money to rid there pasture of weeds. Based on the above information, it is my opinion that pastures with heavy infestations of Canada thistle need complete renovation. Therefore, the use of a broadcast treatment would better serve the producer and legume can be reseeded after a safe amount of time. Rope-wick treatments could then be utilized to spot treat after the broadcast treatment has reduced population.

The decision to control tall ironweed with rope-wick or a broadcast treatment depends on tall ironweed population. Table 5.1 shows the cost of rope-wick treatments based on the amount of herbicides need to treat one acre. High populations would better justify broadcast treatments to clean up the majority of the pasture. ForeFront R&P applied broadcast controlled greater than 80% of tall ironweed for about $13 per acre. Eliminating 80% or more of the tall ironweed and having a greater benefit of controlling smaller weeds such as horsenettle and thistles in the same pasture would benefit the producer. After initial pasture clean up, the rope-wick treatments could be utilized to spot treat and keep tall ironweed populations reduced.

Low infestations of tall ironweed and Canada thistle could be managed well with rope-wick treatments and minimal cost. The size of the rope-wick applicator will determine the volume of total herbicide mixture needed. The larger the rope-wick applicator the more total mixture needed to fill and soak the ropes. Small rope-wick applicators, like the one used in this experiment required 1.8 gallons of herbicide mixture to fill the rope-wick, therefore, it would cost at least $117 fill and to obtain 63 to 66% tall ironweeds control. When analyzing tall ironweed and Canada thistle control with rope-wick treatments, population of weeds as well as cost, should be considered. A majority of weedy pastures would benefit more from a broadcast treatment than a rope-wick treatment because greater control of more weed species would occur.

**Table 5. 1: Estimated Herbicide Cost of Rope-Wick for Tall Ironweed and Canada Thistle Control in Fayette and Boone Counties in 2007.**

| Herbicide | Estimated $/gallon | Application Method | Amount | % Contro1 1 YAT | | Estimated herbicide cost per acre (No. of gallons required to treat 1 acre) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 * | 3** | 1 | 2 | 3 | 4 | 5 |
| **Milestone** | $293 | Rope-Wick | 1% | 28 | 15 | $3 | $6 | $9 | $12 | $15 |
| **Milestone** | $293 | Rope-Wick | 10% | 36 | 25 | $29 | $59 | $88 | $117 | $147 |
| **Milestone** | $293 | Rope-Wick | 20% | 66 | 23 | $59 | $117 | $176 | $234 | $293 |
| **Roundup Weather Max** | $79 | Rope-Wick | 50% | 34 | 0 | $40 | $77 | $119 | $154 | $198 |
| **Remedy Ultra** | $117 | Rope-Wick | 20% | 23 | 0 | $23 | $57 | $70 | $114 | $117 |
| **Stinger** | $418 | Rope-Wick | 20% | 23 | 8 | $84 | $167 | $251 | $334 | $418 |

* Pooled tall ironweed data from Fayette and Boone Counties in 2007.
** Canada Thistle control from Fayette County in 2007

**Table 5. 2: Comparison of Estimated Herbicide Costs of Rope-Wick and Broadcast Treatments for Tall Ironweed Control in Boone County in 2007.**

| Herbicide | Estimated $/gallon | Application Method | Amount | % Contro1 1 YAT[1] | Broadcast Cost per Acre | Estimated herbicide cost per acre (No. of gallons required to treat 1 acre) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 | 2 | 3 | 4 | 5 |
| **Milestone** | $293 | Rope-Wick | 1% | 11 | - | $3 | $6 | $9 | $12 | $15 |
| **Milestone** | $293 | Rope-Wick | 10% | 16 | - | $29 | $59 | $88 | $117 | $147 |
| **Milestone** | $293 | Rope-Wick | 20% | 63 | - | $59 | $117 | $176 | $234 | $293 |
| **Roundup WeatherMax** | $79 | Rope-Wick | 50% | 50 | - | $40 | $77 | $119 | $154 | $198 |
| **Remedy Ultra** | $117 | Rope-Wick | 20% | 29 | - | $23 | $57 | $70 | $114 | $117 |
| **Stinger** | $418 | Rope-Wick | 20% | 29 | - | $84 | $167 | $251 | $334 | $418 |
| **ForeFront R&P** | $50 | Broadcast | 2 pt/A | 87 | $13 | - | - | - | - | - |
| **Milestone** | $293 | Broadcast | 3 oz/A | 11 | $7 | - | - | - | - | - |
| **Milestone** | $293 | Broadcast | 4 oz/A | 10 | $9 | - | - | - | - | - |
| **Milestone** | $293 | Broadcast | 5 oz/A | 63 | $11 | - | - | - | - | - |
| **PastureGard** | $55 | Broadcast | 2.5 pt/A | 84 | $17 | - | - | - | - | - |
| **Crossbow** | $59 | Broadcast | 2 qt/A | 71 | $29 | - | - | - | - | - |

1. YAT (year after treatment)

**Appendix I: Climate data for Spindletop Research Farm from May 2007 to September 2008 near Lexington, KY.**

| | Air Temperature (°C) | | | | Precipitation (mm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Average | | | | | | Cumulative | |
| **Month** | **Max** | **Min** | **Average** | **Departure from Normal** | **Total** | **Departure from Normal** | **Total** | **Departure from Normal** |
| **May** | 26.1 | 13.3 | 20 | 2 | 37 | -77 | 37 | -77 |
| **June** | 28.9 | 17.2 | 23.3 | 1 | 45 | -48 | 82 | -125 |
| **July** | 28.3 | 17.8 | 23.3 | -1 | 175 | 48 | 257 | -77 |
| **August** | 32.2 | 20.6 | 26.7 | 3 | 65 | -35 | 322 | -111 |
| **September** | 28.9 | 15.6 | 22.2 | 2 | 29 | -52 | 351 | -163 |
| **October** | 22.8 | 11.7 | 17.2 | 3 | 134 | 69 | 485 | -18 |
| **November** | 12.8 | 2.2 | 7.8 | 1 | 73 | -14 | 558 | -31 |
| **December** | 8.9 | 0.0 | 4.4 | 2 | 134 | 33 | 692 | 2 |
| **January** | 5.6 | -4.4 | 0.6 | 1 | 117 | 44 | 809 | 46 |
| **February** | 5.6 | -1.7 | 2.2 | 1 | 136 | 55 | 945 | 101 |
| **March** | 12.2 | 2.2 | 7.2 | 1 | 160 | 48 | 1105 | 149 |
| **April** | 17.8 | 7.8 | 12.8 | 0 | 145 | 47 | 1250 | 196 |
| **May** | 21.7 | 11.1 | 16.7 | -1 | 124 | 10 | 1374 | 206 |
| **June** | 28.9 | 17.8 | 23.3 | 1 | 84 | -9 | 1458 | 197 |
| **July** | 30.6 | 18.3 | 24.4 | 0 | 65 | -63 | 1523 | 134 |
| **August** | 30.6 | 17.2 | 23.9 | 0 | 27 | -72 | 1550 | 62 |
| **September** | 28.9 | 15.6 | 22.2 | 2 | 31 | -51 | 1581 | 12 |

**Appendix II: Climate Data from June 2007 through September 2008 for Fayette County, KY**

| | Air Temperature (°C) | | | | Precipitation (mm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Average | | | | | | Cumulative | |
| Month | Max | Min | Average | Departure from Normal | Total | Departure from Normal | Total | Departure from Normal |
| **June** | 30 | 17 | 23 | 2 | 63 | -30 | 63 | -30 |
| **July** | 29 | 18 | 24 | -1 | 162 | 35 | 225 | 5 |
| **August** | 33 | 21 | 27 | 6 | 97 | -3 | 322 | 2 |
| **September** | 29 | 16 | 22 | 4 | 22 | -59 | 344 | -57 |
| **October** | 23 | 12 | 17 | 6 | 166 | 101 | 510 | 44 |
| **November** | 12 | 3 | 8 | 1 | 70 | -16 | 580 | 28 |
| **December** | 8 | 1 | 4 | 4 | 176 | 74 | 756 | 102 |
| **January** | 4 | -3 | 0 | 1 | 99 | 27 | 855 | 129 |
| **February** | 6 | -2 | 2 | 1 | 155 | 74 | 1010 | 202 |
| **March** | 12 | 2 | 7 | 0 | 160 | 49 | 1170 | 251 |
| **April** | 18 | 8 | 13 | 0 | 150 | 51 | 1320 | 302 |
| **May** | 22 | 11 | 17 | -2 | 110 | -4 | 1430 | 298 |
| **June** | 29 | 18 | 23 | 2 | 91 | -2 | 1521 | 297 |
| **July** | 30 | 18 | 24 | 0 | 87 | -40 | 1608 | 256 |
| **August** | 30 | 17 | 24 | 0 | 55 | -44 | 1663 | 212 |
| **September** | 28 | 16 | 22 | 4 | 36 | -45 | 1699 | 167 |

**Appendix III: Climate Data from June 2007 through September 2008 for Boone County, KY.**

| | Air Temperature (°C) | | | | Precipitation (mm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Average | | | | | | Cumulative | |
| Month | Max | Min | Average | Departure from Normal | Total | Departure from Normal | Total | Departure from Normal |
| **June** | 30 | 17 | 24 | 3 | 47 | -50 | 47 | -50 |
| **July** | 30 | 18 | 24 | -1 | 49 | -59 | 96 | -109 |
| **August** | 34 | 21 | 28 | 7 | 13 | -72 | 109 | -181 |
| **September** | 30 | 16 | 23 | 4 | 63 | -10 | 172 | -191 |
| **October** | 22 | 11 | 17 | 5 | 180 | 107 | 352 | -84 |
| **November** | 11 | 2 | 7 | -2 | 69 | -19 | 421 | -103 |
| **December** | 6 | -1 | 2 | -1 | 143 | 63 | 564 | -40 |
| **January** | 3 | -5 | -1 | -2 | 54 | 12 | 618 | -28 |
| **February** | 3 | -3 | 0 | -4 | 131 | 62 | 748 | 35 |
| **March** | 9 | 1 | 5 | -4 | 242 | 134 | 990 | 169 |
| **April** | 18 | 7 | 13 | -1 | 70 | -25 | 1060 | 144 |
| **May** | 22 | 11 | 16 | -3 | 161 | 52 | 1221 | 195 |
| **June** | 29 | 17 | 23 | 1 | 132 | 35 | 1353 | 230 |
| **July** | 29 | 18 | 24 | -1 | 80 | -27 | 1433 | 203 |
| **August** | 29 | 18 | 24 | 0 | 45 | -40 | 1478 | 163 |
| **September** | 28 | 16 | 22 | 2 | 31 | -42 | 1509 | 121 |

**Appendix IV: Horsenettle Populations and Spiny Amaranth Percent Visual Control Data Take in Fayette County, KY in 2008.**

| Treatment | Rate/ Concentration | Horsenettle Population 10 sq m | | Spiny Amaranth % Visual Control | |
|---|---|---|---|---|---|
| | | Initial | 1 YAT | 8 WAT | 1 YAT |
| **Aminopyralid + 2,4-D** | 92 + 800 g a.e./ha | 72 | - | 95 | - |
| **Aminopyralid** | 1% | 52 | - | 98 | - |
| **Aminopyralid** | 10% | 53 | - | 92 | - |
| **Aminopyralid** | 20% | 40 | - | 90 | - |
| **Glyphosate** | 50% | 62 | - | 75 | - |
| **Triclopyr** | 20% | 45 | - | 83 | - |
| **Clopyralid** | 20% | 63 | - | 79 | - |
| **Untreated Check** | | 63 | - | 0 | - |

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May 5, 2009
(Date)