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16. Abstract

Escort® (metsulfuron methyl) and Transline® (clopyralid) herbicides were evaluated for musk thistle (Carduus nutans L.) management along roadsides near Hereford and Kerrville. Musk thistles were sprayed in the rosette stage on February 26, 1992, near Kerrville and April 21, 1992, near Hereford. Transline® at 5.3, 10.7, and 14.1 fluid ounces/acre (389, 779, and 1029 milliliters/hectare) caused curling and yellowing of leaves and stems after 1 month and killed almost all musk thistles within 2 months. Transline® prevented further musk thistle reinvasion through the last rating period. Escort® at 0.5, 0.75, and 1 ounce/acre (35.0, 52.5, and 70.0 grams/hectare) killed the central growing point of musk thistles within 1 month and killed almost all the original thistles within 2 months at both sites. However, small, uninjured thistles appeared in the Escort® plots after 3 months at both locations.

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CONTROL OF MUSK THISTLE (CARDUUS NUTANS L.) WITH TRANSLINE® AND ESCORT® ALONG ROADSIDES

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IMPLEMENTATION STATEMENT

The responses of musk thistle (Carduus nutans L.) to Escort® and Transline® are documented and compared. The best treatments are offered for field-scale testing and the development of applications for operational use along roadsides.

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation.

Tradenames are used for convenience only, and do not constitute an endorsement of these materials by either the Texas Department of Transportation or Texas Transportation Institute (TTI), nor is it a recommendation over comparable products not named.

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LIST OF ABBREVIATIONS/SYMBOLS

Abbreviation/Symbol	Item
A	Acre
ae	Acid equivalent
ai	Active ingredient
cm	Centimeter(s)
ft	Foot(feet)
g	Gram(s)
gal	Gallon(s)
gal/A	Gallon(s) per acre
ha	Hectare(s)
kg	Kilogram(s)
kPa	Kilopascal(s)
km	Kilometer(s)
l	Liter(s)
lb	Pound(s)
m	Meter(s)
ml	Milliliter(s)
MAT	Month(s) after treatment
oz	Ounce(s)
%	Percent
psi	Pounds per square inch
®	Tradename

SUMMARY

Escort® (metsulfuron methyl) and Transline® (clopyralid) herbicides were evaluated for musk thistle (Carduus nutans L.) management along roadsides in TxDOT Districts 4 (Hereford) and 15 (Kerrville). We sprayed musk thistles in the rosette stage. The area near Kerrville was sprayed February 26, 1992, and two areas near Hereford were sprayed April 21, 1992. Plots were evaluated 1, 2, and 3 months after spraying at both sites; plots near Kerrville were also rated 2 weeks and 4 months after spraying. Transline® at 5.3, 10.7, and 14.1 fluid ounces (oz)/acre (A), corresponding to 389, 779, and 1029 milliliters (ml)/hectare (ha), caused curling and yellowing of leaves and stems after 1 month and killed almost all musk thistles within 2 months. Transline® prevented further musk thistle reinvasion through the last rating period. Escort® at 0.5, 0.75, and 1 ounce product/A (35.0, 52.5, and 70.0 g product/ha) killed the central growing point of musk thistles within 1 month and killed almost all the original thistles within 2 months at both sites. However, small, uninjured thistles had appeared in the Escort® plots after 3 months at both locations. Unsprayed thistles grew to a maximum height of 8 ft (2.4 m) near Kerrville and 7 ft (2.1 m) near Hereford. Escort® and Transline® killed upright prairie coneflower [Ratibita columnifera (Nutt.) Woot. & Sandl.] and bur-clover (Medicago polymorpha L.) near Kerrville. Escort® also killed common horehound (Marrubium vulgare L.) near Kerrville.

CONTROL OF MUSK THISTLE (CARDUUS NUTANS L.) WITH TRANSLINE® AND ESCORT® ALONG ROADSIDES

INTRODUCTION

The purpose of this study was to develop effective and economical methods for controlling musk thistle (Carduus nutans L.) along roadsides and to encourage replacement by shorter, more desirable vegetation, thus improving sight distance, enhancing roadside beauty, and improving public relations.

Musk thistle is an aggressive, unsightly, and troublesome weed. It is an erect, herbaceous plant that usually grows to 6 ft (1.8 m) or more and is a native of Europe and Western Asia (Anonymous, Weed Identification Guide). Musk thistle behaves primarily as a biennial, but it may be a winter annual or a summer annual under the favorable conditions of abundant winter or summer rainfall (Feldman et al. 1968 and McCarty and Scifres 1969). A high percentage of seed germinate soon after dissemination without special treatment (Andersen 1968 and McCarty et al. 1969).

Musk thistle forms a basal rosette of coarsely lobed, spiny, waxy, pale green leaves. Stems are erect, branched, and spiny with wing-like projections. Flowers occur in heads about 1.25-3 inches (3.2-7.6 cm) in diameter, primarily from May through July in Texas. One plant may produce more than 10,000 seeds. The plant produces a large, fleshy, hollow taproot. Its taxonomic characteristics are described in more detail elsewhere (Anonymous, Weed Identification Guide, Correll and Johnston 1970, McCarty et al. 1967, and Nilson and Fick 1989). Its germination characteristics and life cycle have been described (Hamrick and Lee 1987, Lacefield and Gray 1970, Lee and Hamrick 1983, McCarty and Scifres 1969, and McCarty et al. 1969).

Musk thistle presently occurs in about 40 states of the United States (Anonymous, Weed Identification Guide, and Dunn 1976) and is listed on the noxious weed seed list of 16 states and Canada (Anonymous, Canada Seeds Act 1992, and Anonymous, State Seed Law Index 1992).

In Texas, musk thistle occurs mostly in the Edwards Plateau, but it also has been found in the Panhandle near Hereford and on the Blackland Prairies near Waxahachie. The plant is widely distributed in the Edwards Plateau, but it occurs in limited infestations around Hereford and Waxahachie where it may have been introduced in hay or on vehicles from other infestations. It occurs most often in thin stands but may grow in widely scattered, small, thick stands. Musk thistle has been found in Blanco, Deaf Smith, Edwards, Ellis, Gillespie, Kerr, Kimble, Mason, McCulloch, Real, and Sutton counties of Texas (National Agricultural Pest Information System 1991). Musk thistle commonly grows on roadsides, pastures, and waste places.

Herbicides have been tried for controlling musk thistle. In Nebraska, Feldman et al. (1968) found that picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) was effective at 0.25 lb/A (0.28 kg/ha)[1] applied April through June and at 0.125 lb/A (0.14 kg/ha) in October. They achieved excellent control of musk thistle using 2 lb/A (2.24 kg/ha) of 2,4-D [(2,4-dichlorophenoxy)acetic acid] when applied in May or October. Dicamba (3,6-dichloro-2-methoxybenzoic acid) gave good control when applied at a rate of 1 lb/A (1.12 kg/ha) in April and May. The most effective control using these growth-regulating materials generally occurred when the plants were in the rosette stage before stem elongation had occurred.

Roeth (1979) found that fall applications of picloram at 0.13 lb/A (0.14 kg/ha) controlled musk thistle in the rosette stage better and more consistently than either 2 lb/A (2.24 kg/ha) of 2,4-D or 0.5 lb/A (0.56 kg/ha) of dicamba. Treatment of bolted stems with all herbicides did not produce satisfactory results. Picloram was more effective than the other two herbicides when applied during dry weather.

Popay et al. (1989) found that MCPA [(4-chloro-2-methylphenoxy)acetic acid] at 1.35 lb/A (1.51 kg/ha) and MCPA at 0.89 lb/A (1.0 kg/ha) + clopyralid (3,6-dichloro-2-pyridinecarboxylic acid) at 0.027 lb/A (0.030 kg/ha) killed 82-85% of the thistles in New

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[1]In the Introduction, rates of liquid herbicides are presented in acid equivalents (ae) or active ingredients (ai) as pounds/acre and kilograms/hectare. Dry herbicide formulation rates are presented in ae or ai of product as ounces/acre and grams/hectare.

Zealand. They also suggested than genetic differences may influence the response of musk thistle to herbicides.

Cargill et al. (1991) found that clopyralid at 0.125, 0.25, and 0.5 lb/A (0.14, 0.28, and 0.56 kg/ha); dicamba at 1 lb/A (1.12 kg/ha); picloram at 0.5 lb/A (0.56 kg/ha); and triclopyr {[(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid} at 0.75 and 1.0 lb/A (0.84 and 1.12 kg/ha), all at acid equivalent rates, gave significantly better control 2 and 3 months after treatment (MAT) than either Escort® {metsulfuron methyl or 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid} at 1 oz 60% product (70.0 g/ha) or Glean® {chlorsulfuron or 2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide} at 1 oz 75% product (70.0 g/ha).

Beck (1991) and Beck et al. (1990) summarized the control of musk thistle, indicating that Glean® at 0.75 oz/A of 75% product (52.5 g/ha) or Escort® 0.5 oz/A of 60% product (35.0 g/ha) will eliminate seed production if applied in the bolting to bud growth stages; whereas, seed production still will occur if auxin-type herbicides are applied at this late stage. Also, Glean® and Escort® treatments may be compatible with the use of the musk thistle seedhead weevil (Rhinocyllus conicus) if applied when the lateral shoots are in the bolting to early bud stage and early developing heads are in the bloom stage. This allows the weevil to complete its life cycle in the early heads, either reducing or eliminating seed formation while the herbicides eliminate later seed production (Beck 1991 and Rees 1986).

No recommended treatment has been developed for musk thistle control in Texas. Therefore, research is needed to develop a recommendation that is effective, economical, and free from environmental problems relative to highway vegetation management and adjoining farming and ranching operations.

THE PROBLEM

Musk thistle is an aggressive, unsightly, and troublesome weed invading roadsides and nearby disturbed (cultivated) areas on farm and ranch land where it is a potential seed source. Once established along roadsides, the plants can produce large quantities of seed which are readily blown to adjoining areas where dense stands of plants occasionally form. Thus, these infestations cause a public relations problem with the local farmers and ranchers.

Musk thistle is an unsightly plant. It may grow to 8 ft (2.4 m) tall, rising high above desirable roadside vegetation. Toward maturity, the plant develops an unsightly appearance with the stem gradually dying back and flower heads in various degrees of maturity from red to white with drifting seed. The spiny leaves and stems are also a problem for anyone walking along the roadside and for livestock in pastures.

Mowing often is used to remove the plant tops after bolting has begun but before the flower heads form. This procedure is effective if done several times during the growing season by cutting off all the plants when producing stems. However, the cost is prohibitive on roadsides, especially since mowing times will be limited in the future due to reduced budgets.

Any successful method of control must essentially kill all the existing plants in every stage of growth. Because of musk thistle's prolific seed production capability, only a few surviving plants can reseed a large area. The method must be economical and not hazardous to humans, livestock, wildlife, or desirable vegetation. Consequently, developing an efficient, rapid, safe herbicide treatment appears more promising for use along highways than do either mowing or insect biological control methods.

MATERIALS AND METHODS

We conducted two tests on dense stands of musk thistle growing along highways at two Texas locations. One location was situated on the south side of State Highway 27 approximately 17 miles (27.4 km) northwest of Kerrville between FM 479 and Mountain Home. The other location was within 3 miles (4.8 km) of Hereford. One third of the plots near Hereford were established on US 60 about 1.5 miles (2.4 km) southwest of the junction with US 385. Two thirds of the plots were set up on FM 2943 about 0.25 mile (0.40 km) north of its junction with FM 1259.

Three sets of plots with all treatments were established at each site. Near Kerrville, plots 20 x 30 ft (6.1 x 9.1 m) were used in a continuous row along the south side of State Highway 27. Near Hereford, plots 10 x 60 ft (3.1 x 18.3 m) were used. One set of plots was established along US 60 on the median along the northeast bound lane. The other two sets of plots were established on the west side of FM 2493. One set of plots bordered the pavement edge of the southbound lane; the other set of plots adjoined the back slope next to a wheat field.

The tests at both sites consisted of seven treatments including Escort® at 0.5, 0.75, and 1 oz product/A (35.0, 52.5, and 70.0 g product/ha)[2]; Transline® at 5.3, 10.7, and 14.1 fluid oz/A (389, 778, and 1029 ml/ha); and untreated plots. Escort® product consisted of 60% ae of metsulfuron methyl, and Transline® contained 3 lb/gal (359 g ae/l) of the monoethanolamine salt of clopyralid. All herbicide treatments included the surfactant, X-77® at the rate of 0.25% by volume of spray. X-77® contains alkylaryl= polyoxyethylene, glycols, free fatty acids, and isopropanol.

We made applications by using a wheel-mounted experimental plot sprayer. A 3-nozzle boom gave a 5-ft (1.5 m) spray swath using compressed air at 30 psi (207 kPa) and yielded a spray volume rate of 25 gal/A (234 l/ha).

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[2]In the remainder of this paper, herbicide rates are given as product. Liquid herbicides are presented as fluid ounces/acre and milliliters/hectare; dry herbicide formulation rates are presented as solid ounces/per acre and grams/hectare.

At the time of spraying on February 26, 1992, near Kerrville and April 21, 1992, near Hereford, musk thistle plants in the plots were almost entirely in the rosette stage. A few had begun to bolt near Hereford with stems up to 2 ft (0.61 m) tall. The musk thistle plants were designated into three classes according to rosette size: small - 0-9.9 inches (0-25.1 cm) in diameter, medium - 10-14.9 inches (25.4-37.8 cm) in diameter, and large - 15 inches (38.1 cm) in diameter and above. The largest were about 20 inches (50.8 cm) in diameter.

Up to 10 plants in each size class per plot were rated for the percentage of injury at time of spraying at both sites and 0.5, 1, 2, 3, and 4 months after treatment (MAT) near Kerrville and 1, 2, and 3 MAT near Hereford. The extent of injury was based on the amount of leaf and stem yellowing (chlorosis), curling, and death (necrosis); death of the central growing point; and death of the plant. By 2 MAT, plants killed by herbicide treatments had often decayed to the point that they could not be identified. Therefore, musk thistles not found after the initial rating were recorded as dead. Notes and sometimes similar ratings of other plant species in the plots were recorded at each evaluation date.

Means for percent injury of musk thistle recorded 0.5, 1, 2, 3, and 4 MAT near Kerrville and 1, 2, and 3 MAT near Hereford are presented. Musk thistle data were subjected to analyses of variance, and means were separated at the 5% level using Duncan's multiple range test.

RESULTS AND DISCUSSION

Musk Thistle

Kerrville. At time of spraying in February, all plants were in the rosette stage with diameters up to about 20 inches (50.8 cm). By 1 MAT, untreated plants had produced stems up to about 2 ft (0.61 m) tall with immature infloresences. At 2 MAT, untreated plants averaged about 4 ft (1.2 m) tall with a few heads having produced mature seed. A few plants in a swale adjoining the plots were as much as 8 ft (2.4 m) tall (Figure 1). By 3 MAT, most of the plants in the area adjoining the plots were 3-6 ft (0.92-1.8 m) tall with most having some mature heads. At 4 MAT, almost all plants had flower heads in all stages of development with about a third having mature seed.

On March 9, 2 weeks after spraying, Transline® had caused more injury than Escort® (Table 1). The highest rate of Transline® was slightly more injurious to musk thistle than the two lower rates. Transline® caused the leaves and stems to curl and to turn yellowish green. Escort® killed the growing point at the center of the musk thistle rosettes but caused little curling or yellowing of the leaves. There were no differences in herbicide effectiveness among plant sizes.

On March 24, 1 MAT, Transline® had caused 73-98% foliar injury with most of the musk thistles dead (Table 1). The highest rate was slightly more effective than the two lower rates. Escort® had caused 38-49% foliar injury and had killed some of the thistles. However, even though the growing point had been killed and the plant prevented from bolting, some of the rosette leaves remained partially or entirely green. Musk thistle plant size was not important for control with either herbicide.

On April 23, 2 MAT, every rate of Transline® had killed essentially all musk thistles in the three size groups (Figure 2A and 2B)(Table 2). The plants had turned brown and disintegrated such that it was difficult to find remnants of the leaves and stems. Escort® had killed most of the plants giving overall treatment injury ratings of 84-

Figure 1. A musk thistle plant 8 ft (2.4 m) tall near Kerrville, Texas on April 23, 1992.

Table 1. Percent injury of three size classes of musk thistle near Kerrville, Texas, 2 weeks and 1 month after application on February 26, 1992 of three rates each of Transline® and Escort®.

Treatment[1]	Rate product[2]	Date rated[3]					
		2-Week			1-Month		
		Small	Medium	Large	Small	Medium	Large
	(Amt/A)	(Percent Injury - 0%=No effect; 100%=Dead plant)					
1. Trans-line® + X-77®	5.3 oz + 0.25%	28b	29b	30b	89b	84b	73c
2. Trans-line® + X-77®	10.7 oz + 0.25%	29b	32b	33b	87b	79b	83b
3. Trans-line® + X-77®	14.1 oz + 0.25%	39a	45a	40a	98a	95a	91a
4. Escort® + X-77®	0.5 oz + 0.25%	4d	5cd	7c	41c	40d	39d
5. Escort® + X-77®	0.75 oz + 0.25%	7c	7c	8c	38c	43cd	41d
6. Escort® + X-77®	1.0 oz + 0.25%	4d	6cd	8c	40c	49c	42d
7. Untre-ated		2d	3d	3d	3d	3e	3e

[1]Chemicals: Transline® = 3 lb/gal (359 g ae/l) monoethanolamine salt of clopyralid, Escort® = 60% ae metsulfuron methyl, X-77® = a non-ionic surfactant.

[2]Acre rates of Transline® are based on fluid ounce of product, Escort® (not 60% ae metsulfuron methyl) on ounce of solid product, and X-77® on volume/volume quantities of spray solution applied applied at a 25 gal/A (234 l/ha) rate. Rates of 5.3, 10.7, and

Table 1. (Cont.)

14.1 fluid oz/A correspond to 389, 779, and 1029 ml/ha, respectively. Rates of 0.5, 0.75, and 1 oz/A correspond to 35.0, 52.5, and 70.0 g/ha, respectively.

[3]Injury ratings were made March 9 (2-week) and March 24 (1-month), 1992, after spraying. Plant rosette size classes: small = 0-9.9-inch (0-25.1 cm) diameter, medium = 10-14.9-inch (25.4-37.8 cm) diameter, large = 15-inch (38.1 cm) and larger diameter. Values in columns followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

A

B

Figure 2. Musk thistle area near Kerrville, Texas on April 23, 1992. A. Untreated plot. B. Plot sprayed with 5.3 fluid oz/A (389 ml/ha) of Transline® on February 24, 1992.

Table 2. Percent injury of three size classes of musk thistle near Kerrville, Texas, 2, 3, and 4 months after application on February 26, 1992 of three rates each of Transline® and Escort®.

Treatment[1]	Rate[2] product	Date rated[3]								
		2-Month			3-Month			4-Month		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	(Amt/A)	(Percent Injury - 0% = No effect; 100% = Dead plant)								
1. Transline® + X-77®	5.3 oz + 0.25%	99a	99a	98a	100a	100a	99a	97a	100a	100a
2. Transline® + X-77®	10.7 oz + 0.25%	100a	100a	100a	100a	100a	100a	100a	100a	100a
3. Transline® + X-77®	14.1 oz + 0.25%	100a	100a	100a	100a	100a	100a	100a	100a	100a
4. Escort® + X-77®	0.5 oz + 0.25%	84d	86c	92b	5c	49d	87b	50b	24d	14d
5. Escort® + X-77®	0.75 oz + 0.25%	96b	94b	91b	5c	68c	94ab	56b	68b	65c
6. Escort® + X-77®	1.0 oz + 0.25%	91c	92b	92b	21b	87b	100a	62b	41c	81b
7. Untreated		1e	1d	1c	5c	5e	5c	8c	8e	19d

Table 2. (Cont.)

[1]Chemicals: Transline® = 3 lb/gal (359 g ae/l) monoethanolamine salt of clopyralid, Escort® = 60% ae metsulfuron methyl, X-77® = a non-ionic surfactant.

[2]Acre rates of Transline® are based on fluid ounce of product, Escort® (not 60% ae metsulfuron methyl) on ounce of solid product, and X-77® on volume/volume quantities of spray solution applied at a 25 gal/A (234 l/ha) rate. Rates of 5.3, 10.7, and 14.1 oz/A correspond to 389, 779, and 1029 ml/ha, respectively. Rates of 0.5, 0.75, and 1 oz/A correspond to 35.0, 52.5, and 70.0 g/ha, respectively.

[3]Injury ratings were made April 23 (2-month), May 20 (3-month), and June 17 (4-month) after spraying.

Plant rosette size classes: Small = 0-9.9-inch (0-25.1 cm) diameter, medium = 10-14.9-inch (25.4-37.8 cm) diameter, large = 15-inch (38.1 cm) and larger diameter. Values in columns followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

96%. Escort® at 0.5 oz/A (35.0 g/ha) seemed to be slightly less effective on the two smallest plant size classes than the other treatments. Again, the original plants had decayed and were difficult to find.

On May 20, 3 MAT, the plots had inadvertantly been mowed. Essentially all musk thistles had died in the Transline® plots (Table 2). A number of new, small and a few medium-size plants were present in the Escort® treatments, however, resulting in low injury ratings. The highest Escort® rate was slightly more effective for preventing musk thistle reinfestation than the lowest rate. No critical investigation was made as to the origin of new plants because the original plants were difficult to find. In a few cases, however, plants had grown back from buds on the original plants, but most seemed to have originated from seed. Most were in the rosette stage; however, a few had bolted, producing a stem about 2 ft (0.61 m) tall. Untreated plot data are presented for untreated and unmowed plants in areas adjoining the plots. A few of the untreated plants seemed to have been killed by the mowing operation.

By June 17, 4 MAT, musk thistles remained almost completely controlled in the Transline® plots; only a few new small ones were present at the lowest rate of treatment (Table 2). Escort® had killed the original thistles, but it had allowed reinvasion by many new plants. Most new plants were about 2 ft (0.61 m) tall with flower heads varying from immature to mature and shedding seed.

Thus, near Kerrville, Transline® killed nearly all musk thistles at the rates used and prevented reinfestation by new plants, at least through 4 MAT. Future research using lower rates of Transline® is needed to develop the most economical, yet efficient treatment for roadsides on the Edwards Plateau. Escort® appeared to kill almost all of the original plants, but it allowed reinvasion of new musk thistles within 3 MAT. At 4 MAT, plants in the Escort® plots were blooming and producing seed.

Hereford. Musk thistles in the Texas Panhandle developed much later than those near Kerrville. Consequently, plants near Hereford were not sprayed until April 21, 1992. At this time, most of the musk thistles were still in the rosette stage up to about

20 inches (50.8 cm) in diameter, but a few had bolted producing stems up to about 2 ft (0.61 m) tall. No rating was made 2 weeks after spraying because of the cool weather which slowed growth, the long travel distance, and the fact that no plants had died 2 weeks after spraying near Kerrville.

On May 19, 1 MAT, Transline® had caused 40-100% foliar plant injury with many of the plants dead, particularly at the two highest rates (Table 3). Escort® killed the growing points at the center of the rosettes and some leaves, but few plants.

On June 15, 2 MAT, Transline® had killed almost all musk thistle plants at the two higher rates and the small plants at 5.3 oz/A (389 ml/ha) (Table 3). At this time, the foliage of the dead plants had broken down, making the plants difficult to find. Escort® also had killed most of the plants. The foliage on the remaining plants was severely injured.

On July 15, 3 MAT, almost all of the original plants had died in both the Transline® and the Escort® treatments (Table 3). However, small plants occurred in the Escort® treatments, particularly in plots sprayed with the lowest rate. These plants were about 1 ft (0.30 m) tall and were flowering.

At Hereford, Transline® and Escort® killed almost all the original musk thistle plants at the rates used. Transline® kept musk thistle plants out of the plots through 3 MAT. Escort®, however, allowed reinvasion by small plants within 3 MAT, especially at rates of 0.5 and 0.75 oz/A (35.0 and 52.5 g/ha).

Overall at both sites, Transline® was more effective than Escort® for killing musk thistles and preventing reinvasion by new plants. Both herbicides show promise for controlling musk thistle, but Transline® provides a longer period of control. Thus, Transline® at 5.3 oz/A (389 ml/ha) is the first choice for spraying followed by Escort® at 0.5 oz/A (35.0 g/ha). Either of these herbicides will kill essentially all the musk thistles present in the rosette stage without disrupting other vegetation along the roadside. A second Escort® spraying, however, may be necessary the same year, at least near Kerrville.

Table 3. Percent injury of three size classes of musk thistle near Hereford, Texas, 1, 2, and 3 months after application on April 21, 1992 of three rates each of Transline® and Escort®.

Treatment[1]	Rate[2] product	Date rated[3]								
		1-Month			2-Month			3-Month		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	(Amt/A)	(Percent Injury - 0% =No effect; 100% =Dead plant)								
1. Transline® + X-77®	5.3 oz + 0.25%	72b	46c	40cd	95ab	80c	70d	100a	98a	95b
2. Transline® + X-77®	10.7 oz + 0.25%	100a	70b	63b	98a	99a	92b	100a	100a	96b
3. Transline® + X-77®	14.1 oz + 0.25%	89a	92a	80a	100a	99a	99a	100a	100a	100a
4. Escort® + X-77®	0.5 oz + 0.25%	35c	40c	38d	83c	89b	92b	6c	100a	100a
5. Escort® + X-77®	0.75 oz + 0.25%	39c	46c	44cd	85c	81c	80c	51b	100a	99a
6. Escort® + X-77®	1.0 oz + 0.25%	40c	38c	47c	89bc	87b	83c	83a	100a	100a

Table 3. (Cont.)

7. Untreated	6d	5d	5e	5d	5d	5e	19c	23b	22c

[1]Chemicals: Transline® = 3 lb/gal (359 g ae/l) monoethanolamine salt of clopyralid, Escort® = 60% ae metsulfuron methyl, X-77® = a non-ionic surfactant.

[2]Acre rates of Transline® are based on fluid ounce of product, Escort® (not 60% ae metsulfuron methyl) on ounce of solid product, and X-77® on volume/volume quantities of spray solution applied at a 25 gal/A (234 l/ha) rate. Rates of 5.3, 10.7, and 14.1 oz/A correspond to 389, 779, and 1029 ml/ha, respectively. Rates of 0.5, 0.75, and 1 oz/A correspond to 35.0, 52.5, and 70.0 g/ha, respectively.

[3]Injury ratings were made May 19 (1-month), June 15 (2-months) and July 15 (3-months), 1992, after spraying. Plant rosette size classes: Small = 0-9.9-inch (0-25.1 cm) diameter, medium = 10 to 14.9-inch (25.4-37.8 cm) diameter, large = 15-inch (38.1 cm) and larger diameter. Values in columns followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Other herbicides such as picloram, 2,4-D, and dicamba can be effective for private land owners on their farms and ranches but not for the Texas Department of Transportation (TxDOT) which does not use restricted herbicides.

Mowing can be effective for controlling musk thistle. However, several mowings each year will be necessary to prevent seed maturation because progressively more plants become established throughout the growing season.

One of the major problems in spraying will be to identify plants from the spray truck. The most effective time to spray is when the plants are in the rosette stage. Dense overstory vegetation, like tansymustard [Descurainia pinnata (Walt.) Britt.] near Hereford, can hide the musk thistle rosettes. Areas to spray in the Edwards Plateau will be especially difficult to identify since the plants are generally thinly scattered along the roadside. Consequently, the areas to be treated will either have to be marked prior to spraying or a second person will need to ride the spray truck and operate the sprayer.

Further research is needed to establish the lowest Transline® rate necessary to control musk thistle under various environmental conditions. Also, an effective method, other than the present herbicides, is needed for controlling musk thistle once stem elongation has started and the plants are in all stages of development.

Other Species

Kerrville. Both Transline® and Escort® killed upright prairie coneflower [Ratibita columnifera (Nutt.) Woot. & Sandl.] and bur-clover (Medicago polymorpha L.) within 2 MAT (April). Escort® killed common horehound (Marrubium vulgare L.), a noxious range weed that lowers wool quality, by 3 MAT (May). The following uninjured plant species were found in plots of all treatments, including the untreated areas after 2 months: Dillens oxalis (Oxalis dillenii Jacq.), Dakota vervain (Verbena bipinnatifida Nutt.), johnsongrass [Sorghum halepense (L.) Pers.], and Texas wintergrass (Stipa leucotricha Trin. & Rupr.). Additionally, blue vervain (Verbena hasta L.), silverleaf nightshade (Solanum elaeagnifolium Cav.), sideoats grama [Bouteloua curtipendula

(Michx.) Torr.], and windmillgrass (Chloris verticillata Nutt.) were identified at the end of 3 months (May). Subsequently, knotroot bristlegrass [Setaria geniculata (Lam.) Beauv.] and silver bluestem [Bothriochloa laguroides (DC.) Herter] had headed out after 4 months (June). Henbit (Lamium amplexicaule L.), nodding brome (Bromus anomalus Repr. ex Fourn.), and rescuegrass (Bromus catharticus Vahl) grew up and died naturally during the experiment.

Hereford. Tansymustard was in flower and completely foliated in dense stands in almost all plots on FM 2493 at the time of spraying. The plants were about 2 ft (0.61 m) tall and formed a dense canopy over the musk thistle rosettes. Tansymustard plants had almost completed their life cycle 2 MAT (June) and were completely dead in all plots after 3 months (July). Neither herbicide seemed to control tansymustard.

Little barley (Hordeum pusillum Nutt.), nodding brome, oat (Avena sativa L.), and wheat (Triticum aestivum L.) grew up unaffected and died naturally in all plots during the experiment. Some rescuegrass was still all or partially green at the last rating in July. Both herbicides seemed to cause some short-term injury (1 month) to alfalfa (Medicago sativa L.), but the plants recovered and were flowering by July.

Gray goldaster [Heterotheca canescens DC. (Shinners)], silverleaf nightshade, buffalograss [Buchloe dactyloides (Nutt.) Engelm.], johnsongrass, and Kentucky bluegrass (Poa pratensis L.) were present and uninjured 2 MAT. Palmer amaranth (Amaranthus palmeri S. Wats.), green sprangletop [Leptochloa dubia (Kunth in H.B.K.) Nees], King Ranch bluestem [Bothriochloa ischaemum (L.) Keng var. songarica (Fisch. & Mey.), green bristlegrass [Setaria viridis (L.) Beauv.], sideoats grama, and windmillgrass were headed out at 3 MAT (July). Palmer amaranth was present up to 2.5 ft (0.76 m) tall, and a few plants were flowering in July. By July, johnsongrass, 3-4 ft (0.92-1.2 m) tall and headed out, and common mallow (Malva neglecta Wallr.) were present and not injured in many plots.

Thus, the species composition varied somewhat between Kerrville and Hereford. Vegetative growth near Hereford developed later than near Kerrville. Both herbicides controlled a few species other than musk thistle, but neither herbicide caused bare ground. Some of the winter annual species completed their life cycle during the experiments. Other species, however, soon became established in an uninjured condition in all plots.

CONCLUSIONS

1. Transline® effectively controlled musk thistle near both Kerrville and Hereford at rates of 5.3-14.1 fluid oz/A (389-1029 ml/ha).
2. Transline® caused curling and yellowing of musk thistle leaves and stems before killing the plant.
3. Escort® at 0.5 to 1 oz product/A (35.0 to 70.0 g product/ha) killed the original musk thistles at both sites, but some new, small thistles occurred in the plots within 3 MAT.
4. Escort® caused the death of the central growing point before killing the plant.
5. Transline® and Escort® killed upright prairie coneflower and bur-clover near Kerrville.
6. Escort® killed common horehound near Kerrville.
7. Neither herbicide, at the rates, used resulted in either bare ground or an overall deleterious affect on roadside vegetative cover.

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