Drummond's Goldenweed and Its Control with Herbicides

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Abstract

Several selective and nonselective foliar-active herbicides were applied alone and in 1:1 combinations as broadcast sprays in the spring for control of Drummond's goldenweed on the Coastal Prairie of Texas. Picloram at 0.56 kg/ha or picloram plus 2,4,5-T, glyphosate, or atrazine plus paraquat at 1.12 kg/ha consistently controlled the weed. Atrazine and 2,4-D, applied singly or in combination at 1.12 to 2.24 kg/ha total herbicide, effectively controlled Drummond's goldenweed only when soil-water content was high. Dicamba, like 2,4-D, was effective when applied in a "wet" year but not in a "dry" year. The effective herbicides controlled Drummond's goldenweed for at least 3 years. Although Drummond's goldenweed is morphologically similar to common goldenweed, it is apparently more susceptible to herbicides than its western counterpart.

Drummond's goldenweed [*Isocoma drummondii* (T. & G.) Greene] has traditionally been considered a minor component of vegetation of the southern Gulf Prairies and Marshes of Texas. However, during the past decade, it has become increasingly important and is now a significant weed problem on about 1 million ha of rangeland south and west of Corpus Christi. It also occurs as isolated stands in the eastern South Texas Plains, where a closely related species, common goldenweed [*Isocoma coronopifolia* (Gray) Greene] has become a serious, widespread range management problem (Mayeux et al. 1979). Drummond's goldenweed normally occurs as scattered individuals in the understory of woody plant communities on rangelands. However, upon removal of the brush cover, especially by mechanical methods which disturb the soil, goldenweed may develop dense stands and dominate range sites of moderate to high potential productivity (Mayeux and Scifres 1979).

Drummond's goldenweed is a heavily branched, suffrutescent subshrub with a rounded canopy which is usually 5 to 8 dm tall but may attain a height of 1 m. The leaves are linear and entire or occasionally with small marginal teeth, several centimeters long, and resinous. The flower heads are formed in late fall, are composed of 10 to 30 bright yellow disc florets only, and occur singly or in clusters of as many as 20 at the stem tips. The flowers produce pubescent achenes, 2 to 3 mm long, with a persistent pappus two to three times as long as the achene. A single plant may produce more than 200,000 achenes and new seedling density can exceed 2,600/m^2 (Mayeux and Scifres 1979). However, annual seedling mortality may range from 25 to 100%, depending on site and rainfall during the year of emergence. Stem elongation rates of mature plants average 0.5 to 0.8 mm/day but may proceed at nearly 2 mm/day following rainfall during the growing season on well-drained sites which are not characterized by accumulations of salts and sodium.

Since grazing of native grasslands provides the basis of the local economy of the area of Drummond's goldenweed's maximum adaptation, its spread, thickening of existing stands, and dominance of many sites following brush control have stimulated interest in its control. However, little information is available concerning the response of either Drummond's or common goldenweed to conventional range weed control method. The problem is accentuated by confusion of Drummond's goldenweed with common goldenweed or with "false broomweed" (*Ericameria austrotexana* M.C. Johnston), formerly classified as *Isocoma palmeri* (Gray) Shinners and a common component of the south Texas perennial range weed complex. Mechanical methods which do not cause extensive soil disturbance, such as shredding, are not effective because Drummond's goldenweed rapidly resprouts from lower stems and a woody caudex following top removal. Essentially no information exists concerning the response of Drummond's goldenweed to herbicides.

Common goldenweed, which occurs west of the geographical distributions of Drummond's goldenweed, was controlled with 2,4-D [(2,4-dichlorophenoxy)acetic acid], picloram (4-amino-3,5,6-trichloropicolinic acid), or a 1:1 combination of picloram and 2,4,5-T[(2,4,5-trichlorophenoxy) acetic acid] applied as broadcast sprays in spring or fall if soil water content was adequate for rapid vegetative growth (Mayeux et al., 1979). Since control of common goldenweed with broadcast sprays depended on relatively high amounts of rainfall being received before treatment, responses among locations were erratic and relatively high herbicide rates were required for consistent control. However, forage species responded to goldenweed control with oven-dry standing crop increasing 5 to 10 kg/ha for each 1% reduction in common goldenweed foliar cover.

The objective of this study was to evaluate several herbicides and herbicide combinations for Drummond's goldenweed control. Herbicides other than the phenoxy and related compounds commonly used on rangelands were included because highly susceptible agronomic crops such as cotton (*Gossypium hirsutum* L.) and vegetables are often grown on areas adjacent to rangeland infested with Drummond's goldenweed. Glyphosate [*N*-(phosphonomethyl)glycine] has proven effective for control of several species of perennial weeds on pastures (Johnson 1976) and railroad rights-of-way (Andrews et al. 1974). Glyphosate has also been used successfully for control of perennial range weeds such as Carolina horsenettle (*Solanum carolinense* L.) (Banks and Santelmann 1976) and African rue (*Peganum harmala* L.) (Allen and McCully 1976). Atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine] is used on western rangelands to control weedy grasses and herbaceous broadleaf species (Houston and van der Sluijs 1973), especially in conjunction with grass seedings (Eckert et al. 1974). It also effectively controls silverleaf nightshade (*Solanum eleagnifolium* Cav.) (Johnson et al. 1976) and Canada thistle [*Cirsium arvense* (L.) Scop.] (Carson and Bandeen 1975, Parochetti 1974), and partially controls green rabbitbrush [*Chrysothamnus viscidiflorus* (Hook) Nutt.] when applied at 1 kg/ha

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(Evans and Young 1972). The contact herbicide paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) was evaluated because of its effectiveness against phenoxy-resistant range weeds such as geyer larkspur (*Delphinium geyeri* Green) (Hyder 1972).

Study Area

Control of Drummond's goldenweed was studied on native grassland near Kingsville in Kleberg County, Texas. Experiments were located on a grazing unit with a long history of continuous stocking with cows and calves at about 1 AU/7 ha. A uniform Drummond's goldenweed stand averaging 4,975 plants/ha dominated the site, which had been cleared of brush by chaining 10 years earlier. Average plant age based on growth ring counts (Mayeux and Scifres 1979) was about 6 years. Grasses were primarily species of poor grazing value such as coast sandbur (*Cenchrus incertus* M.S. Curtis), red threeawn (*Aristida longiseta* Steud.), and red lovegrass [*Eragrostis oxylepis* (Torr.)]. Soils are sandy loams of Delfina (Aquic Paleustalfs) and Hildalgo series (Typic Calciustolls). Average annual rainfall is 67 cm, with peaks occurring in May and June and again in September (Shafer and Baker 1973). Soils and vegetation of the study location were described in detail by Mayeux and Scifres (1979).

Materials and Methods

Herbicide treatments evaluated for control of Drummond's goldenweed included the butoxyethanol ester of 2,4-D, the dimethylamine salt of dicamba (3,6-dichloro-*o*-anisic acid), picloram as the potassium salt, glyphosate as an aqueous solution of the isopropylamine salt, atrazine as the 40% suspension, and paraquat as an aqueous solution of the dichloride salt. Equal-ratio combinations of herbicides applied were picloram plus 2,4,5-T as the triethylamine salts and atrazine with 2,4-D or paraquat. Treatments were applied at 1.12 and 2.24 kg/ha total herbicide, except picloram which was also applied alone at 0.56 kg/ha.

All treatments were applied in water containing 0.5% surfactant with a tractor-mounted boom sprayer, which delivered 200 liters/ha of spray solution. Application dates were June 4, 1975, and May 26, 1976. Plot size was 7 by 30 m, and untreated plots were included on both dates. Treatments were replicated four times in a randomized complete block design.

Wind speed, air temperature, and relative humidity were recorded at noon on the days of herbicide application. Soil water content was determined gravimetrically on triplicate soil samples from 0 to 15, 15 to 30, and 30 to 45 cm depths. Observations of Drummond's goldenweed growth stage and apparent vigor were also recorded.

Responses of Drummond's goldenweed were evaluated by recording and averaging visual estimates of percent canopy reduction by three observers at 6 months and 2 and 3 years after herbicide application. Data were subjected to the arcsin $\sqrt{\%}$ transformation before conducing analyses of variance (Steel and Torrie 1960). Data were initially analyzed with year of treatment as the main effect and herbicide treatment as subplot effect. Data from the 2 years were not pooled for presentation since analysis of variance indicated a significant effect of year of application ($P = 0.99$) and a significant year × treatment interaction ($P = 0.95$).

Results and Discussion

Skies were clear, wind speeds were 11 km/hr or less, relative humdity was 58%, and air temperature was 29° C when herbicides were applied to Drummond's goldenweed on June 4, 1975 (Table 1). Air temperature did not differ on May 26, 1976, but wind speed, relative humidity, and soil water content were somewhat higher than in 1975. Soil water contents (wet weight basis) at 0 to 15 and 30 to 45 cm depths were approximately 3 and 10%, respectively, when sprays were applied in 1975. Herbaceous vegetation on the study area wilted briefly on that date, and Drummond's goldenweed was not vigorously developing new stem growth. In late May 1976, however, recent rains had resulted in more favorable growing conditions. Water contents of the two soil depth increments were 12 and 15%, respectively. Drummond's goldenweed stem elongation appeared to be rapid, and considerably more new vegetative growth was evident in comparison with the previous year's.

Table 1. Environmental conditions during herbicide applications to Drummond's goldenweed on June 4, 1975, and May 26, 1976, near Kingsville, Texas.

Year of treatment	Air temp. (C)	Relative humidity (%)	Wind speed (km/hr)	Soil water[1] (%)
1975	29	58	11	3–10
1976	29	74	16	12–15

[1]Values represent means of soil samples from the 0–15 and 30–45 cm depths, respectfully.

No rainfall was recorded on the study site in March or April 1975 and only 6 cm occurred in May. About 4 cm rainfall occurred the month after herbicide application in June 1975. At 6 months after application of treatments under the relatively dry conditions in 1975, 1.12 kg/ha of 2,4-D did not effectively control Drummond's goldenweed; canopy reductions averaged only 65% (Table 2). Although 14 cm of rainfall were received in July 1975, the post-treatment precipitation apparently was too late to favorably influence the response of Drummond's goldenweed to the herbicide. The 2.24 kg/ha rate of 2,4-D reduced Drummond's goldenweed canopy by 82% under the relatively dry conditions. Dicamba was only slightly more effective than 2,4-D at equal rates in 1975.

When applied under more favorable soil moisture conditions in 1976, 1.12 kg/ha of either 2,4-D or dicamba completely controlled Drummond's goldenweed topgrowth by 6 months after application (Table 2). About 26 cm of rainfall were received on the study site during the 60-day period before application of the herbicides in 1976 and about 28 cm were received during the 60 days following treatment. Differences in canopy reductions between years following treatment with 1.12 kg/ha 2,4-D or dicamba were significant. Applications of 2.24 kg/ha of either 2,4-D or dicamba also eliminated Drummond's goldenweed 6 months after application in 1976. Based on these evaluations, responses of Drummond's gol-

Table 2. Canopy reduction (%) of Drummond's goldenweed at 6 months and 2 years after application of various herbicides as broadcast sprays on June 4, 1975, or May 26, 1976, near Kingsville, Texas.

		Canopy reduction by year of treatment[2]			
	Rate[1]	6 months		2 years	
Herbicide(s)	(kg/ha)	1975	1976	1975	1976
None	—	0	0 a	0a	0 a
2,4-D	1.12	65 cd	100 e	40 cd	98 fg
2,4-D	2.24	82 de	100 e	86 fg	100 g
Dicamba	1.12	74 d	99 e	45 cde	83 fg
Dicamba	2.24	99 e	100 e	88 fg	100 g
Picloram	0.56	96 e	100 e	79 fg	100 g
Picloram	1.12	99 e	100 e	95 fg	100 g
Picloram	2.24	100 e	100 e	99 g	100 g
Picloram + 2,4,5-T	1.12	98 e	100 e	83 fg	100 g
Picloram + 2,4,5-T	2.24	99 e	100 e	99 g	100 g
Glyphosate	1.12	87 de	100 e	69 def	100 g
Glyphosate	2.24	89 e	100 e	96 fg	99 g
Paraquat	1.12	95 e	47 bc	84 fg	5 a
Paraquat	2.24	100 e	50 c	96 fg	33 bc
Atrazine	1.12	16 ab	98 e	5 a	100 g
Atrazine	2.24	19 ab	100 e	0 a	100 g
Atrazine + paraquat	1.12	78 de	100 e	73 efg	100 g
Atrazine + paraquat	2.24	98 e	100 e	95 fg	100 g
Atrazine + 2,4-D	1.12	32 bc	98 e	15 ab	94 fg
Atrazine + 2,4-D	2.24	46 bc	99 e	40 cd	99 g

[1]Rates shown are total herbicide applied; all combinations are 1:1 mixtures.
[2]Means followed by the same letter within a time of evaluation do not differ significantly at the 95% level according to Duncan's multiple range test.

denweed to dicamba or 2,4-D are similarly regulated by environmental factors such as soil water availability. Although dicamba is root-absorbed more readily than 2,4-D by some species, which should theoretically improve its potential for weed control, this activity is apparently of little consequence in Drummond's goldenweed control. The equivalence of dicamba and 2,4-D for perennial weed control has been reported with western ironweed (*Vernonia baldwini* Torr.) (McCarty and Scifres 1969), western whorled milkweed [*Asclepias subverticellata* (Gray) Vail] (McCarty and Scifres 1968), and western ragweed (*Ambrosia psilostachya* DC.) (McCarty and Scifres 1972).

Drummond's goldenweed canopy reductions averaged 96 to 100% at 6 months after picloram was applied alone or in combination with 2,4,5-T, regardless of rate of application or year of treatment (Table 2). Although the effectiveness of 2,4-D and dicamba is apparently highly dependent upon environmental stresses, especially reduced soil-water availability, picloram effectiveness may not be seriously reduced by short-term conditions which are less than optimal for activity of other hormone-type herbicides. This improved effectiveness for range weed control has been attributed to the persistent soil activity of picloram (Ueckert et al. 1979). Moreover, the effectiveness of picloram in combination with phenoxy herbicides, particularly 2,4,5-T, offers opportunity for effective broadspectrum perennial weed control when the mixtures are applied primarily for woody plant control.

Glyphosate at 1.12 kg/ha reduced Drummond's goldenweed canopy by 87% 6 months after application in 1975 and essentially eliminated the weed in 1976 (Table 2). Glyphosate at 2.24 kg/ha resulted in excellent control in both years.

Paraquat reduced Drummond's goldenweed canopies by 95 and 100% at 1.12 and 2.24 kg/ha, respectively, when applied in 1975 (Table 2). In contrast, either rate resulted in only about 50% canopy reduction after applications in 1976. Light and temperature, factors which are closely associated with paraquat activity (Ashton and Crafts 1973), were comparable on the two dates of treatment. Effectiveness of paraquat in 1975 was presumed to be augmented by moisture stress. Since paraquat is a contact herbicide which is generally not translocated to a significant extent, perennials generally resprout following top kill. However, Drummond's goldenweed had not resprouted 3 years after paraquat application.

The apparent influence of soil-water availability on herbicide susceptibility of Drummond's goldenweed was most marked in responses to atrazine (Table 2). Atrazine applied alone reduced the weed canopy in 1975 by less than 20%, regardless of rate. Atrazine at either 1.2 or 2.24 kg/ha was five times more effective under the more moist conditions in 1976, compared to results from applications in 1975.

Drummond's goldenweed control with the combination of atrazine and paraquat was more consistent between years than when atrazine alone was applied. Canopy reductions ranged from 78 to 100% at 6 months after applications of the atrazine-paraquat mixture in 1975, compared to total control after application in 1976 (Table 2). Synergism is not indicated in either year, since equal rates of the herbicides applied alone resulted in weed control levels equivalent to those from the mixture during both years of treatment. Apparently, paraquat was primarily responsible for the effectiveness of the mixture in 1975, and atrazine was the principal herbicidal agent in the combination in 1976.

At 6 months after application in 1975, the combination of atrazine and 2,4-D was less effective than 2,4-D applied alone but tended to be more effective than atrazine alone applied at 1.12 or 2.24 kg/ha (Table 2). Either rate of the atrazine plus 2,4-D mixture effectively controlled Drummond's goldenweed in 1976.

Based on canopy reductions, evaluations after 2 years indicated no differences in the levels of control observed 6 months after treatment on plots where herbicides were initally effective. Where the herbicides were not highly effective after 6 months, some canopy regrowth had occurred by the second year after treatment. For instance, reduction of Drummond's goldenweed canopy cover after application of 1.12 kg/ha 2,4-D in 1975 was 65% at 6 months and 40% after 2 years (Table 2). Where dicamba was applied at 1.12 kg/ha in 1975, canopy reduction was 74% after 6 months but only 45% after 2 years (Table 2). No differences were noted among evaluations conducted after 2 and 3 years. No significant improvement in canopy reduction over initial evaluation was noted for any treatment. Little reestablishment of Drummond's goldenweed seedlings was observed in treated plots as of the 1979 growing season. However, reestablishment from seed produced by the dense infestations surrounding the plots would be expected whenever a year occurs with well-distributed rainfall during the winter, spring, and summer months (Mayeux and Scifres 1978).

Similar experiments have been conducted with common goldenweed under environmental conditions much like those described near Kingsville in 1975 (Mayeux et al. 1979). Based on a comparison with these studies, common and Drummond's goldenweed did not respond similarly to the herbicide applications. Canopy reductions of common goldenweed were generally about half or less of those of Drummond's goldenweed for any given treatment. For instance, 2,4-D at 1.12 kg/ha reduced common goldenweed canopy by only 11% (Mayeux et al. 1979) whereas the same treatment reduced Drummond's goldenweed canopy by 65% in this study (Table 2). Glyphosate was not effective against common goldenweed at either rate, but gave acceptable control of Drummond's goldenweed when applied under similar circumstances. Only picloram at 2.24 kg/ha gave acceptable control of both goldenweed species.

Summary and Conclusions

Drummond's goldenweed was effectively controlled with broadcast sprays of several herbicides and combinations applied at moderate rates. Herbicide 2,4-D was effective at 2.24 kg/ha when soil water content was low but 1.12 kg/ha controlled the weed only when soil-water availability was near optimum. Control with dicamba was similar to that achieved with the same rates of 2,4-D, regardless of soil water content. Picloram alone at 0.56 kg/ha or combined in an equal amount with 2,4,5-T to total 1.12 kg/ha completely controlled Drummond's goldenweed regardless of year applied. Since this treatment is commonly used for brush control in Texas, it offers simultaneous control of perennial weeds such as Drummond's goldenweed.

Among the herbicides evaluated which are not commonly used for range weed and brush control, glyphosate at either 1.12 or 2.24 kg/ha consistently controlled Drummond's goldenweed. Applied alone or with 2,4-D, atrazine was not effective in the "dry" year but controlled the goldenweed during the "wet" year. Atrazine applied with paraquat was more consistent, relative to canopy reduction, while paraquat alone controlled Drummond's goldenweed only when soil-moisture availability was limited.

Since few grasses were present on the heavily grazed study area, effects of the nonselective herbicides on forage species could not be evaluated. Damage to grasses from applications of glyphosate, paraquat, and/or atrazine to varying degrees was observed in this study and would be an important consideration under most circumstances. Glyphosate significantly reduced basal cover of native grasses on the Rio Grande Plains when applied for control of "false broomweed" (Mayeux et al. 1980).

Variability in herbicide tolerance among highly similar members of a homogeneous taxon offers an opportunity to investigate the mechanisms of herbicide tolerance as exhibited by common goldenweed in comparison with Drummond's goldenweed. The variation in responses of the two species to identical treatments applied under similar conditions appears to be greater than were differences in response of Drummond's goldenweed between different soil-moisture conditions. The two goldenweed species apparently do not differ in respect to the requirement of high water availability for optimum responses to most herbicidal sprays, however.

Literature Cited

Allen, T.J., and W.G. McCully. 1976. Preliminary control of African rue

along roadsides with herbicides. Proc. S. Weed Sci. Soc. 29:327-329.
Andrews, O.N., Jr., R.C. Billman, F.D. Timmons. 1974. Glyphosate control of railroad rights-of-way vegetation in the Southeast. Proc. S. Weed Sci. Soc. 27:251-254.
Ashton, F.M., and A.S. Crafts. 1973. Mode of Action of Herbicides. John Wiley and Sons, New York, London, and Toronto. 504 p.
Banks, P.A., and P.W. Santelmann. 1976. Carolina horsenettle susceptibility to glyphosate at varying growth stages. Proc. S. Weed Sci. Soc. 29:402 (abstr.).
Carson, A.G., and J.D. Bandeen. 1975. Chemical control of Canada thistle. Weed Sci. 23:116-118.
Eckert, R.E., Jr., J.E. Asher, M.D. Christensen, and R.E. Evans. 1974. Evaluation of atrazine-fallow technique for weed control and seedling establishment. J. Range Manage. 27:288-292.
Evans, R.A., and J.A. Young. 1977. Weed control-revegetation systems for big sagebrush-downy brome rangelands. J. Range Manage. 30:331-336.
Houston, W.R., and D.H. van der Sluijs. 1973. Increasing crude protein content of forage with atrazine on shortgrass range. U.S. Dep. Agr., Agr. Res. Serv. Prod. Res. Rep. 153. Washington, D.C. 10 p.
Hyder, D.N. 1972. Paraquat kills Geyer larkspur. J. Range Manage. 25:460-464.
Johnson, B.J. 1976. Glyphosate for weed control in dormant bermudagrass. Weed Sci. 24:140-143.
Johnson, J.W., J.R. Abernathy, and J.W. Keeling. 1976. Silverleaf nightshade control with triazine herbicides. Proc. S. Weed Sci. Soc. 29:58 (abstr.).
Mayeux, H.S., Jr., and C.J. Scifres. 1978. Germination of goldenweed seed. J. Range Manage. 31:371-374.
Mayeux, H.S., Jr., and C.J. Scifres. 1979. Vegetative growth and mortality of Drummond's goldenweed [*Isocoma drummondii* (T. & G.) Greene: Compositae] as influenced by soil moisture and site characteristics. Southwest. Natur. 24:97-114.
Mayeux, H.S., Jr., D.L. Drawe, and C.J. Scifres. 1979. Control of common goldenweed with herbicides and associated forage release. J. Range Manage. 32:271-274.
Mayeux, H.S., Jr., C.J. Scifres, and R.A. Crane. 1980. *Ericameria austrotexana* and associated range forage respones to herbicides. Weed Sci. 28:602-606.
McCarty, M.K., and C.J. Scifres. 1968. Western whorled milkweed and its control. Weed Sci. 16:4-7.
McCarty, M.K., and C.J. Scifres. 1969. Herbicidal control of western ironweed. Weed Sci. 17:77-79.
McCarty, M.K., and C.J. Scifres. 1972. Herbicidal control of western ragweed in Nebraska pastures. J. Range Manage. 25:290-292.
Parochetti, J.V. 1974. Canada thistle control with atrazine. Weed Sci. 22:28-31.
Shafer, G.H., and E.T. Baker, Jr. 1973. Ground water resources of Kleberg, Kenedy, and southern Jim Wells Counties, Texas. Tex. Water Devel. Board Rep. 173. Austin. 162 p.
Steel, R.G.D., and J.H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York, London, and Toronto. 481 p.
Ueckert, D.N., C.J. Scifres, S.G. Whisenant, and J.L. Mutz. 1980. Alternative herbicides for overcoming limitations of 2,4-D for control of bitterweed. J. Range Manage. 33:465-469.