Evaluation of Herbicides for Roadside Weed Control in New Mexico

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Highlight: Twenty-eight herbicides or combinations of herbicides were evaluated for selecting control for kochia and Russian thistle in grasses desirable for roadside erosion control: sideoats grama, sand dropseed, western wheatgrass, Indian ricegrass, and threewain. Based on their ability to control weeds without injuring desirable grasses, treatments that were superior to the bromacil standard (2 lb/acre) were: bromoxynil at 0.5 and 1 lb/acre, dicamba at 1 lb/acre, and 2,4-D amine at 3 lb/acre.

The control of annual broadleaved weeds in seedlings of native grasses along roadsides in low rainfall areas of New Mexico (Quimby 1971) is quite different from the control of noxious perennial grasses encountered along highways in higher rainfall areas, e.g., Oklahoma (Huffine et al. 1968), Arkansas (Sckerl et al. 1966), and Mississippi (Hussey 1966; Snuggs 1973). In New Mexico, the Soil Conservation Service has suggested the use of native grasses for "critical area" stabilization (Lohmiller 1971). Dates selected for seeding are those with the highest probability of receiving 0.6 inch or more precipitation during each of two, consecutive, 3-week periods. A minimum probability of 60% is preferred, and dates within the "rainy" season of July, August, and early September are usually selected (Lohmiller 1971; Brammer 1971). Rainfall during these 3 months may constitute about half the annual precipitation for much of the state. Weeds and grasses compete for this limited moisture.

Russian thistle (*Salsola kali* L. var. *tenuifolia* Tausch) and kochia [*Kochia scoparia* (L.) Schrad.] are the worst weed problems in roadside seedlings of native grasses in New Mexico. Mowing is recommended the first year of seeding for the control of Russian thistle when it is the predominant weed. The mowed thistles provide some cover for the soil and shade the new grass seedlings without undue competition. However, even when mowed, kochia competes strongly for water and nutrients, and a dense stand can completely crowd out the grass seedlings. In those areas that cannot be mowed (e.g., along steep slopes in interchanges), Russian thistle and kochia often crowd out new grass seedlings and compete with the established grasses during

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the second and third season after planting. Mowing the newly established grass stands, even for weed control, is undesirable because the young grass seedlings need as much top growth as possible during the first growing season to establish their root system. Moreover, it is difficult to mow all the grass before the weeds get a good start and offer serious competition to the grass.

The purpose of this project was to evaluate herbicides for control of annual weeds, such as kochia and Russian thistle, in established stands of grasses that were planted or had volunteered from indigenous stands along highways in New Mexico.

Materials and Methods

The herbicides were evaluated for: low toxicity to established, desirable grasses; an acceptable level of control of the undesirable annual weeds; and minimum hazard to crops and ornamentals growing adjacent to or within the right-of-way.

The major herbicide previously used by the highway department was bromacil (Table 1), a nonselective soil sterilant, at 2 lb/acre. It was included in the tests, along with another soil sterilant, karbutilate (Table 1) to establish an index of grass injury and weed control for these chemicals.

Fifteen herbicides (Table 1) were applied at various rates and combinations (28 treatments total) to plots replicated in quadruplicate in a randomized complete block design at three locations along Interstate 25 and Interstate 40 in the vicinity of Albuquerque, New Mexico, in August, 1971. These three areas were selected to include as large a number of plant species as possible in the treatments.

Herbicides were applied with a push-type bicycle sprayer delivering 25 gal/acre of carrier on a 36-inch wide strip. A nonionic surfactant at 0.5% (v/v) was included with all treatments. Treated areas were mowed at irregular intervals by the New Mexico State Highway

Table 1. List of herbicides evaluated in 1971 for control of weeds along roadsides in New Mexico.

Common name	Chemical name
Benefin	N-butyl-N-ethyl- α,α,α -trifluoro-2,6-dinitro- <i>p</i> -toluidine
Bromacil	5-bromo-3- <i>sec</i> -butyl-6-methyluracil
Bromoxynil	3,5-dibromo-4-hydroxybenzonitrile
Chlorflurenol	Methyl 2-chloro-9-hydroxyfluorene-9-carboxylate
2,4-D amide	(2,4-dichlorophenoxy) acetamide
2,4-D amine	(2,4-dichlorophenoxy) acetamine
DCPA	dimethyl tetrachloroterephthalate
Dicamba	3,6-dichloro- <i>o</i> -anisic acid
Fenac	(2,3,6-trichlorophenyl) acetic acid
Karbutilate	<i>tert</i> -butylcarbamic acid ester with 3(<i>m</i> -hydroxyphenyl)-1,1-dimethylurea
Methazole	2-(3,4-dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione
MH	1,2-dihydro-3,6-pyridazinedione
Picloram	4-amino-3,5,6-trichloropicolinic acid
Simazine	2-chloro-4,6-bis(ethylamino)- <i>s</i> -triazine
2,3,6-TBA	2,3,6-trichlorobenzoic acid

Department. Plots were visually evaluated by three or four observers at 3 and 6 weeks after treatment. Weed control and grass injury scores were based on 0 = no injury; 100 = dead. Weed control scores were averages of the two visual estimates of percent kill of weeds and percent injury to weeds at the time of evaluation (postemergence effects) at Tijeras Canyon and Interstate 40 west of Albuquerque. The percent kill of weed seedlings (preemergence effect) was included in the average of Tijeras Canyon where seedlings had emerged after treatment. A performance index score (PI) was calculated for each treatment by subtracting the mean percent injury to grasses (all locations) from the mean weed control score. The data were subjected to analyses of variance and standard errors of means ($S_{\bar{x}}$) and coefficients of variation (CV) were calculated. The means were compared with Duncan's multiple range test at the .01 level of significance.

Highway Areas Selected for Herbicide Evaluation

Location 1

This area was located east of Tijeras Canyon on the median of I-40 and began about 100 ft west of the State Road 217 overpass. The median was about 60 ft wide; the plots were approximately 50 ft long. The Highway Department had reseeded the area. The predominant grass was western wheatgrass (*Agropyron smithii* Rydb.) with some squirreltail [*Sitanion hystrix* (Nutt.) J. G. Smith], Kentucky bluegrass (*Poa pratensis* L.), sideoats grama [*Bouteloua curtipendula* Michx. (Torr.)], and sand dropseed [*Sporobolus cryptandrus* (Torr.) A. Gray]. Kochia had developed to a good stand over most of the area. Weed control and grass tolerance to the various herbicides were evaluated. This area was sufficiently large to permit untreated plots between each treatment. Soils were loams to heavy clay loams ("B" horizon exposed by construction).

Location 2

This area was located west of Albuquerque on the median of I-40 about 2 miles west of the Central Avenue Interchange. The median was 100 ft wide and was seeded to sideoats and blue grama [*Bouteloua gracilis* (H.B.K.) Lag.]. Some Indian ricegrass [*Oryzopsis hymenoides* (Roem. & Schult.) Ricker] on the drier slopes, sand dropseed, Russian thistle, and kochia were also present. Plots were 80 ft long, with untreated plots located between each treatment. Soils were loamy to fine sandy loam (mixed road fill).

Location 3

The area was located near Sandia Pueblo on I-25 in the right-of-way on the west side of the highway.

Grasses present were indigenous to the area (approximately 60% threeawn (*Aristida* spp.), 35% Indian ricegrass, and 5% sand dropseed). The soil is a fine sandy loam with some surface gravel. The plots were 60 ft long, with untreated plots between each treatment. The main reason for selecting this site was the presence of the Indian ricegrass. Weeds were sparse, and only tolerance of the grasses to the herbicides was tested.

Results and Discussion

Weed Control Scores

Weed control scores were higher at Location 2 (I-40), west of Albuquerque than at Location 1 (Tijeras Canyon) with the same chemicals (Table 2), perhaps because the soil was sandier at Location 2. Some of the treatments varied considerably in their effects at the different locations. When averaged over the two locations, two soil sterilant treatments, bromacil at 2 lb/acre and karbutilate at 2 lb/acre, provided significantly higher weed control scores than nine other treatments. Only four of the treatments, fenac at 2 lb/acre, simazine at 1 lb/acre, chlorflurenol + MH at 1+1 lb/acre, and chlorflurenol at 3 lb/acre, had significantly lower weed control scores than the 13 treatments that produced weed control scores of 70 or higher.

Table 2. Mean weed control scores for herbicides evaluated 3 and 6 weeks after application in August, 1971, for control of Russian thistle and kochia along roadsides at Tijeras Canyon and Interstate 40 (I-40) 2 miles west of Albuquerque, N. Mex.

Treatment	Rate (lb/acre)	Location		
		Tijeras Canyon (score)	I-40 west of Albuquerque (score)	Mean (score)
Bromacil	2	100 a ¹	100 a	100 a
Karbutilate	2	97 a	100 a	98 a
2,4-D amine + methazole	1+3	95 a	98 a	96 ab
Karbutilate	1	86 ab	100 a	93 ab
2,4-D amine + methazole	1+1	77 abc	100 a	88 abc
Dicamba	1	66 bcd	100 a	83 a-d
Bromoxynil	1	66 bcd	100 a	83 a-d
2,4-D amine	3	58 cd	91 a	74 a-d
2,4-D amine + DCPA	1+4	65 bcd	82 ab	74 a-d
Dicamba	0.5	57 cd	90 a	73 a-e
Bromoxynil	0.5	47 def	98 a	73 a-e
2,4-D amine + 2,4-D amide	1+2	54 cde	89 a	72 a-e
2,4-D amine + 2,4-D amide	1+1	53 cde	89 a	71 a-e
2,4-D amine	2	55 cd	81 ab	68 a-f
2,4-D amine + fenac	1+3	47 def	88 ab	68 a-f
2,4-D amine	1	44 def	88 ab	66 a-f
Picloram + 2,4-D amine	0.25+0.5	44 def	86 ab	65 a-f
2,4-D amine + Benefin	1+1	40 d-g	89 a	64 a-f
2,4-D amine + fenac	0.5+1.5	26 fgh	95 a	60 a-f
2,4-D amine + Benefin	1+1.5	27 e-h	88 ab	58 b-g
2,4-D amine + DCPA	1+8	27 e-h	72 abc	50 c-h
2,3,6-TBA	2	24 fgh	74 abc	49 c-i
2,3,6-TBA	4	26 fgh	61 bcd	44 d-i
Fenac	4.5	14 gh	50 cd	32 e-i
Fenac	2	15 gh	44 d	30 f-i
Simazine	1	5 h	40 de	22 ghi
Chlorflurenol + MH	1+1	6 h	18 e	12 hi
Chlorflurenol	3	4 h	18 e	11 i
$S_{\bar{x}}$, CV		6.3, 26%	6.5, 17%	8.8, 20%

¹ Values followed by the same letter within a column are not significantly different at the .01 level according to Duncan's multiple range test.

Most of the treatments could not be separated on the basis of statistical analysis. Excluding the soil sterilant treatments, 17 of the treatments produced weed control scores that were not significantly different at the .01 level.

Simazine at 1 lb/acre would not be expected to exert much post-emergence effect on existing weeds, but results from previous tests showed this chemical provided good pre-emergence control of Russian thistle in a sandy soil. Also, chlorflurenol, a growth inhibitor, would not be expected to provide weed kill (Harris et al. 1971). Unfortunately, a good evaluation of growth inhibition was not possible because the plots were mowed.

Kill of weed seedlings (preemergence effect) paralleled the postemergence effects. Bromoxynil was not effective as a pre-emergence treatment. This response was expected because bromoxynil is a contact-type herbicide with little activity through the soil. Simazine at 1 lb/acre did not perform well as a preemergence herbicide. A higher rate might have resulted in better performance.

Injury to Grass

In contrast to the poor separation of treatments with respect to weed control, differences with respect to injury to the grasses were quite obvious (Table 3). As averaged over three locations, the two soil sterilants produced significantly greater injury to the grasses than did all other treatments. The other treatments produced an average of less than 25% injury to the grasses and none of these treatments were significantly different.

Table 3. Mean visual estimates of percentage of grass injury caused by herbicides evaluated 3 and 6 weeks after application in August, 1971, for weed control along roadsides at Tijeras Canyon, Interstate 40 (I-40) 2 miles west of Albuquerque, and Interstate 25 (I-25) at Sandia Pueblo.

Treatment	Rate	Location			Mean (%)
		Tijeras Canyon ¹ (%)	I-40 west of Albuquerque ² (%)	I-25 at Sandia Pueblo ³ (%)	
Karbutilate	2	82 a ⁴	100 a	62 a	81 a
Karbutilate	1	72 a	95 a	45 abc	71 a
Bromacil	2	85 a	58 b	55 ab	66 a
2,4-D amine + methazole	1+3	32 bc	8 c	30 bcd	23 b
2,3,6-TBA	2	25 cd	8 c	28 cde	20 b
2,3,6-TBA	4	32 bc	12 c	2 de	15 b
Simazine	1	40 b	0 c	5 de	15 b
Fenac	4.5	10 e	5 c	18 de	11 b
2,4-D amine + methazone	1+1	12 de	0 c	15 de	9 b
2,4-D aine + DCPA	1+1	12 de	2 c	12 de	9 b
2,4-D amine + 2,4-D amide	1+2	8 e	2 c	15 de	8 b
2,4-D amine + fenac	1+3	5 e	2 c	18 de	8 b
Dicamba	0.5	10 e	5 c	5 de	7 b
Dicamba	1	8 e	8 c	5 de	7 b
Chlorflurenol + MH	1+1	5 e	0 c	12 de	6 b
2,4-D amine + DCPA	1+8	0 e	0 c	18 de	6 b
Fenac	2	0 e	0 c	15 de	5 b
Chlorflurenol	3	2 e	2 c	5 de	3 b
Bromoxynil	0.5	0 e	0 c	8 de	3 b
2,4-D amine + Benefin	1+1	5 e	2 c	0 e	2 b
2,4-D amine + fenac	1.5+1.5	5 e	0 c	2 de	2 b
2,4-D amine	2	0 e	0 c	8 de	2 b
2,4-D amine	3	2 e	2 c	2 de	2 b
Picloram + 2,4-D amine	0.25+0.5	5 e	0 c	0 e	2 b
2,4-D amine + 2,4-D amide	1+1	0 e	0 c	2 de	1 b
2,4-D amine + Benefin	1+1.5	0 e	0 c	0 e	0 b
2,4-D amine	1	0 e	0 c	0 e	0 b
Bromoxynil	1	0 e	0 c	0 e	0 b
S $\bar{x}$, CV	3.4,41.8%	3.0,53%	5.5,96%	5.7,71%	

¹ Principal grass was western wheatgrass.

² Principal grasses were sideoats and blue grama.

³ Principal grasses were threeawn, Indian ricegrass, and sand dropseed.

⁴ Values followed by the same letter within a column are not significantly different at the .01 level according to Duncan's multiple range test.

Simazine at 1 lb/acre injured (40%) western wheatgrass at Location 1 (Tijeras Canyon) but did not appreciably injure the other grass species at the other two locations (see footnotes 1, 2, and 3 at bottom of Table 3). Also, the combination of 2,4-D amine and methazole at 1+3 lb/acre injured western wheatgrass at Location 1 and threeawn, Indian ricegrass, and sand dropseed at Location 3 (I-25 at Sandia Pueblo). This injury was apparently caused by the methazole because 2,4-D alone did not harm the grasses. The combination of 2,4-D - methazole at 1+1 lb/acre injured western wheatgrass significantly less than did the combination with the higher rate (3 lb/acre) of methazole. No injury to any of the grasses at any of the locations was detected for bromoxynil at 1 lb/acre, 2,4-D amine at 1 lb/acre, or for 2,4-D amine + benefin at 1+1.5 lb/acre. At Location 2 (I-40, west of Albuquerque), 1 month after treatment, sideoats grama appeared to be more resistant than blue grama to bromacil at 2 lb/acre.

The results with the soil sterilants generally agreed with those of others (Bowmer and McCully 1969), clearly showing that this type of chemical should only be used in those areas requiring total vegetation control.

Performance Index

A performance index was calculated for each treatment (Table 4). The Performance Index, or PI, was equal to the Weed

Control Score (Table 2) minus Percent Injury to Grass (Table 3). In general, the performance indices for a given treatment were quite consistent in relative rank over all locations. However, PI scores were generally higher for Location 2 (I-40, west of Albuquerque) than for Location 1 (Tijeras Canyon). This relationship reflected the generally better weed control at Location 2 (Table 2).

Bromacil at 2 lb/acre was selected as a standard for comparison because it was already in use in some highway department districts. Seven treatments had significantly higher PI values than bromacil (Table 4). These seven treatments were: bromoxynil at 0.5 or 1 lb/acre, 2,4-D amine + methazole at 1+1 lb/acre, dicamba at 1 lb/acre, 2,4-D amine at 3 lb/acre, and 2,4-D amine + 2,4-D amide at 1+1 lb/acre. Methazole is not registered for noncropland use. Also, 2,4-D amide is not readily available at present. Four treatments, bromoxynil at 0.5 or 1 lb/acre, dicamba at 1 lb/acre, and 2,4-D amine at 3 lb/acre, are currently cleared and registered for noncropland use.

All three of these herbicides would be acceptable for use along highway rights-of-way, except where spray drift or vapors could come into contact with sensitive crop plants or ornamentals. Under these conditions, bromoxynil is probably the least hazardous because it is a nonvolatile, contact-type herbicide. If bromoxynil or 2,4-D amine is used, retreatment may be necessary when a new crop of weeds appears because residual activity of these herbicides in soil is short.

Conclusions and Recommendations

Bromoxynil at recommended rates is relatively nontoxic to

Table 4. Performance Index (PI) calculated from weed control scores (average for two locations) and injury to grasses (average of three locations) as visually estimated for herbicides evaluated for control of Russian thistle and kochia along roadsides in New Mexico.

Treatment	Weed Control - Grass Injury = Perf. Index			
	Rate (lb/acre)	(Score)	(%)	(PI)
Bromoxynil	1	83 a-d ¹	0 b	83 a
2,4-D amine + methazole	1+1	88 abc	9 b	79 a
Dicamba	1	83 abc	7 b	76 a
2,4-D amine + methazole	1+3	96 ab	23 b	73 ab
2,4-D amine	3	74 a-d	2 b	72 ab
2,4-D aine + 2,4-D amide	1+1	71 a-e	1 b	70 ab
Bromoxynil	0.5	73 a-e	3 b	70 ab
2,4-D amine	1	66 a-f	0 b	66 abc
Dicamba	0.5	73 a-e	7 b	66 abc
2,4-D amine	2	68 a-f	2 b	66 abc
2,4-D amine + DCPA	1+4	74 a-d	9 b	65 abc
2,4-D amine + 2,4-D amide	1+2	72 a-e	8 b	64 abc
Picloram + 2,4-D amine	0.25+0.5	65 a-f	2 b	63 abc
2,4-D amine + Benefin	1+1	65 a-f	2 b	63 abc
2,4-D amine-fenac	1+3	68 a-f	8 b	60 a-d
2,4-D amine + fenac	0.5+1.5	60 a-g	2 b	58 a-d
2,4-D amine + Benefin	1+1.5	58 b-g	0 b	58 a-d
2,4-D amine + DCPA	1+8	50 ch	6 b	44 b-e
Bromacil (STANDARD)	2	100 a	66 a	34 c-f
2,3,6-TBA	2	49	20 b	29 def
2,3,6-TBA	4	44 d-i	15 b	29 def
Fenac	2	30 f-i	5 b	25 ef
Karbutilate	1	93 ab	71 a	22 ef
Fenac	4.5	32 e-i	11 b	21 ef
Karbutilate	2	98 a	81 a	17 ef
Chlorflurenol	3	11 i	3 b	8 f
Simazine	1	22 ghi	15 b	7 f
Chlorflurenol + MH	1+1	12 hi	6 b	6 f
S $\bar{x}$, CV	8.8, 20%	5.7, 71%	7.5, 26%	

¹ Values followed by the same letter within a column are not significantly different at the .01 level according to Duncan's multiple range test.

grasses in all stages of growth. This chemical will provide excellent weed control on newly seeded roadsides and on established stands of grass where annual broadleafed weeds are a problem. Although it is now routinely used by the New Mexico State Highway Department, additional research is desirable on the safety and efficiency of bromoxynil for use in vegetation management along roadsides in New Mexico where climate, soils, and grasses vary so much among different locations.

In tests conducted in 1970, simazine gave excellent pre-emergence weed control. Its low toxicity to established warm-season grasses indicated that this chemical deserves further evaluation for preemergence control of weeds where warm-season grasses are the dominant species.

Chlorflurenol is a specialty chemical developed to suppress growth of plants, not to kill them. This study indicated that it does not kill kochia or Russian Thistle, but evaluation of growth suppression was not possible because the plots were mowed.

Bromacil and karbutilate are effective soil-sterilants. However, bromacil and karbutilate should be compared experimentally to determine which is the least dangerous to the environment. They should be compared for long-term residual weed control and for danger to desirable plants caused by lateral movement of herbicide as a result of leaching and runoff with

sediments under the varying conditions found in New Mexico.

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