# Effects of Herbicides on Germination and Seedling Development of Three Native Grasses

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**Abstract**

**Two experiments conducted in growth chambers examined influences of 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid], chlopyralid (3,6-dichloropicolinic acid), picloram (4-amino-3,5,6-trichloropicolinic acid), and triclopyr {[3,5,6-trichloro-2-pyridinyl)-oxy]acetic acid} on germination and early seedling development of buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.], blue grama [*Bouteloua gracilis* (H.B.K.) Lag. *ex* Griffiths], and sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.]. Germination and plumule growth were largely unaffected by chlopyralid but were significantly reduced by 2,4,5-T, picloram, and triclopyr, especially at rates greater than 1.1 kg/ha. Blue grama was less affected by herbicides than either buffalograss or sideoats grama.**

While effects of herbicides on target species have received major attention in the literature, relatively little research has been conducted on herbicidal effects on nontarget desirable species (Scifres and Halifax 1972b). Scifres and Halifax (1972a) observed that picloram acid at 1 mg/L did not affect germination of buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.], sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], or switch grass (*Panicum virgatum* L.), but early seedling growth was affected. Baur (1978) found that applications of pelleted or liquid picloram at rates as high as 3.4 kg/ha did not affect establishment of ryegrass (*Lolium perenne* L.) pastures. Conversely, Arnold and Santelmann (1966) found that preemergence applications of picloram at 0.84 kg/ha prevented emergence of blue grama [*Bouteloua gracilis* (H.B.K.) Laq. *ex* Griffiths] and sideoats grama from soil. Sideoats grama was injured by picloram at rates up to 2.2 kg/ha (Bovey et al. 1979). Scifres and Halifax (1972b) indicated that applications of picloram prior to or following range seeding could complicate seedling establishment.

Although phenoxy herbicides toxic to broadleaved species are not usually toxic to grasses, several researchers (Brock et al. 1970, Getzendaner et al. 1969, Morton et al. 1967) have noted that grass species absorb herbicides, at least for a short time following foliar application. Lee (1970) observed when established stands of creeping bentgrass (*Agrostis palustris* Huds., var. Penncross and Seaside), Kentucky bluegrass (*Poa pratensis* L., var. Newport), perennial ryegrass var. Linn, Italian ryegrass (*Lolium multiflorum* Lam., var. Gulf), tall fescue (*Festuca arundinacea* Schreb., var. Alta), and creeping red fescue (*Festuca rubra* L., var. Pennlawn) were treated with up to 2.2 kg/ha of picloram, the germination percentage of seed produced did not differ significantly from check plots. Canode (1974) indicated that September applications of picloram at rates up to 3.4 kg/ha did not significantly reduce seed germination of Kentucky bluegrass, smooth bromegrass (*Bromus inermis* Leyss.), orchardgrass (*Dactylis glomerata* L.), crested wheatgrass [*Agropyron desertorum* (Fisch.) *ex.* Link Schult.], and red fescue. April application of picloram at rates above 1.7 kg/ha reduced germination of bromegrass and red fescue seed. Bovey and Meyer (1981) found kleingrass and certain grass crop species were more tolerant to broadcast applications of 2,4,5-T, triclopyr, and chlopyralid than broadleaf crops, and triclopyr was usually more phytotoxic than the other herbicides.

The objective of this study was to quantify the effects of 4 commercially formulated herbicides, presently considered for brush management, on germination and early growth of 3 major range grasses.

## Materials and Methods

Two identical experiments were conducted to determine effects of commercially formulated herbicides on seed germination and seedling development. Each experiment involved treating 3 species of grass seed with various rates of 4 herbicides. A completely randomized design was selected, utilizing 4 replications. The herbicides consisted of the propylene glycol butyl ether ester of 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid], the monoethanolamine salt of chlopyralid (3,6-dichloropicolinic acid), the potassium salt of picloram (4-amino-3,5,6-trichloropicolinic acid), and the butoxyethyl ester of triclopyr {[(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid}. The herbicidal effects on seed germination and seedling development were determined using 2 bunchgrasses, blue grama var. common and sideoats grama var. el reno, and 1 sodgrass, buffalograss var. texoka. All 3 species are important components of the herbaceous vegetation of Southwestern rangelands.

Fungi control was accomplished by applying 2.6 g of 50% Captan {N-[(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide} per k of seed. Herbicides were applied in distilled water at equivalent rates (g/unit area) of 0.3, 0.6, 1.1, 2.2, 4.5, and 9.0 kg/ha (ae) to petri dishes containing 25 seeds of a grass species underlain by Whatman #2 filter paper. Herbicide solutions were introduced into the petri dishes by pipeting 2 ml of herbicide:distilled water mixture.

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The petri dishes were placed in an environmental growth chamber calibrated to provide 16 h of light at 30° C and 8 h of darkness at 25° C. High humidity was maintained by placing open containers of distilled water in the chamber. Relative humidity ranged from 50 to 60% for the duration of the study. The petri dishes were watered daily with distilled water to insure adequate moisture for seed germination and seedling growth. The stacks of petri dishes were rotated every 3 to 5 days by moving the bottom dish to the top of the stack allowing better light distribution among replications.

The percentage of seeds germinated was determined at 7, 14, and 28-day intervals. At 7 days, a subsample of 5 seeds from each replicate was selected, their plumule lengths were measured, averaged, and considered as an observation for the replicate. Germinated seeds at the 14 and 28-day intervals were removed, counted, and discarded. Radical lengths were not measured because radical penetration of the filter paper prevented intact removal of the primary root.

Seed germination and plumule growth data from 2 experiments were pooled and plumule lengths were converted to a percentage of the control. Overall differences among herbicides and herbicide by rate interactions were determined by two-way analysis of variance. Data for each grass species were subjected to a series of one-way analyses of variance to identify differences among rates of a herbicide and among herbicides at a particular rate. Comparison of mean plumule length and mean germination percentage was accomplished using least significant difference (LSD) ($P\leq0.05$ and $P\leq0.1$) and Duncan's multiple range test ($P\leq0.05$), respectively, for all treatments with significant *F*-values (Steel and Torrie, 1960).

## Results and Discussion

### Germination

Germination was defined as the protrusion of the radical from the seed. Species germination was affected by herbicide and rate. Although total germination was considered complete at the end of 28 days, the length of time required for germination was not significantly affected by herbicide or rate. In all treated grass species that germinated, 90% of the total germination was completed after 7 days and 97% was completed after 14 days. Each species showed an all or none reaction. If seeds germinated, the treatments were not significantly different ($P\leq0.05$) from the contol or other treatments. However, when germination was affected, it was totally suppressed.

Buffalograss germination was suppressed by picloram and triclopyr at rates greater than 1.1 kg/ha and by 2,4,5-T at 9.0 kg/ha (Table 1). Sideoats grama response was similar to buffalograss, except sideoats grama was tolerant to triclopyr at rates of 2.2 kg/ha and less. Blue grama more effectively tolerated the herbicides than did buffalograss or sideoats grama. Germination of blue grama was suppressed by herbicide rates of 4.5 kg/ha and greater when treated with picloram and triclopyr and by the 9.0 kg/ha rate when treated with 2,4,5-T. The herbicide chlopyralid did not significantly ($P\leq0.05$) affect germination of buffalograss, blue grama, or sideoats grama.

**Table 2. General comparisons of plumule growth (as percentage of control) of each grass species for each herbicide (as a mean for all rates of that herbicide).[1]**

| Herbicides | Buffalograss | Blue grama | Sideoats grama |
|---|---|---|---|
| | | (%) | |
| 2,4,5-T | 55.8 b | 64.7 b | 50.3 b |
| Chlopyralid | 89.1 a | 102.6 a | 90.7 a |
| Picloram | 42.8 d | 66.1 d | 44.3 b |
| Triclopyr | 47.3 c | 53.7 c | 44.8 b |

[1]Means within a column not followed by the same letter are significantly different ($P\leq0.05$) according to LSD.

### Plumule growth.

Radical development was prevented by some herbicides; however, none of the herbicides prevented plumule development, plumule growth data were collected for all treatments without regard to the survival of the seeds. Two-way analysis of variance of

**Table 1. Final germination percentage of grass species by treatment.[1]**

| Herbicide | 0 | 0.3 | 0.6 | 1.1 | Rate (kg/ha) 2.2 | 4.5 | 9.0 |
|---|---|---|---|---|---|---|---|
| | | | | | (%) | | |
| | | | | | Buffalograss | | |
| Control | 40abc | — | — | — | — | — | — |
| 2,4,5-T | — | 51a | 44ab | 37bc | 39bc | 43abc | 0d |
| Chlopyralid | — | 42abc | 45ab | 43abc | 41abc | 32c | 34bc |
| Picloram | — | 36bc | 39bc | 45ab | 0d | 0d | 0d |
| Triclopyr | — | 39bc | 36bc | 36bc | 0d | 0d | 0d |
| | | | | | Blue grama | | |
| Control | 57ab | — | — | — | — | — | — |
| 2,4,5-T | — | 62ab | 57ab | 64ab | 65ab | 56ab | 0c |
| Chlopyralid | — | 55ab | 59ab | 59ab | 60ab | 52ab | 61ab |
| Picloram | — | 59ab | 48b | 67a | 56ab | 0c | 0c |
| Triclopyr | — | 53ab | 54ab | 58ab | 48b | 0c | 0c |
| | | | | | Sideoats grama | | |
| Control | 86abcd | — | — | — | — | — | — |
| 2,4,5-T | — | 68cd | 93ab | 98a | 79abcd | 90abc | 0f |
| Chlopyralid | — | 81abcd | 70cd | 45e | 89abc | 89abc | 76bcd |
| Picloram | — | 94ab | 77abcd | 80abcd | 0f | 0f | 0f |
| Triclopyr | — | 83abcd | 69cd | 85abcd | 66d | 0f | 0f |

[1]Means within species followed by the same letter are not significantly different ($P\leq0.05$) according to Duncan's multiple range test.

Table 3. Rate and herbicide comparisons of species plumule growth as a percentage of the control.[1]

| | Rate (kg/ha) 0.3 | 0.6 | 1.1 | 2.2 | 4.5 | 9.0 | LSD 0.05 |
|---|---|---|---|---|---|---|---|
| | | | | | (%) | | |
| | | | | | Buffalograss | | |
| 2,4,5-T | 67.9 | 63.3 | 65.4 | 60.4 | 41.4 | 36.5 | 10.2 |
| Chlopyralid | 90.2 | 97.4 | 96.2 | 85.0 | 83.8 | 82.1 | N.S. |
| Picloram | 50.3 | 45.7 | 43.0 | 40.9 | 39.8 | 35.1 | N.S. |
| Triclopyr | 59.0 | 57.6 | 43.4 | 44.6 | 42.4 | 37.1 | 8.9 |
| LSD 0.05 | 10.7 | 9.3 | 13.7 | 11.0 | 9.7 | 9.3 | |
| | | | | | Blue grama | | |
| 2,4,5-T | 77.6 | 79.8 | 70.6 | 70.7 | 49.3 | 39.8 | 20.9 |
| Chlopyralid | 94.9 | 105.8 | 102.0 | 99.9 | 101.7 | 111.2 | N.S. |
| Picloram | 76.2 | 79.4 | 67.8 | 63.1 | 59.7 | 50.2 | N.S. |
| Triclopyr | 71.6 | 68.1 | 59.4 | 47.6 | 40.5 | 35.2 | 17.9 |
| LSD 0.05 | N.S. | N.S. | 21.5 | 19.8 | 21.0 | 18.3 | |
| | | | | | Sideoats grama | | |
| 2,4,5-T | 67.9 | 68.5 | 48.9 | 43.4 | 37.0 | 36.1 | 17.2 |
| Chlopyralid | 94.4 | 97.0 | 96.1 | 90.4 | 83.3 | 83.0 | N.S. |
| Picloram | 56.8 | 56.0 | 48.4 | 35.9 | 38.5 | 30.1 | 14.3 |
| Triclopyr | 68.1 | 53.8 | 40.1 | 49.2 | 33.1 | 24.3 | 14.5 |
| LSD 0.05 | 17.3 | 15.8 | 15.2 | 15.5 | 15.5 | 14.8 | |

[1]The plumule length of the controls were 29.2, 26.4, and 51.0 (mm) for buffalograss, blue grama and sideoats grama, respectively. Actual plumule lengths for treatments may be determined by multiplying the respective species control times the decimal percent of the treatment.

plumule lengths failed to show a significant herbicide by rate interaction; however, significant differences occurred among herbicides. Plumule growth of buffalograss was significantly ($P \leq 0.01$) reduced by all herbicides (Table 2). Treatments of picloram, triclopyr, 2,4,5-T, and chlopyralid resulted in plumule growths of 42.8, 47.3, 55.8, and 89.1% of the control, respectively. Picloram and triclopyr were the most detrimental to plumule growth, while chlopyralid was the least damaging of the 4 herbicides.

Plumule growth of sideoats grama responded similarly to buffalograss, being adversely affected by all herbicides. Chlopyralid was less damaging than other herbicides, with plumule growth being 90.7% that of the control. In contrast, sideoats grama seedlings treated with picloram, triclopyr, and 2,4,5-T had plumule lengths 44.3, 44.8, and 50.3% of the control treatment, respectively.

Blue grama was the most tolerant species to herbicide treatments. Blue grama seedlings were unaffected by chlopyralid, whereas, picloram, triclopyr, and 2,4,5-T significantly ($P \leq 0.01$) reduced plumule growth. Triclopyr was the most damaging herbicide, reducing plumule growth by 46.3% (Table 2).

Increasing rates of herbicides from 0.3 to 9.0 kg/ha generally reduced plumule growth of buffalograss (Table 3). Triclopyr and 2,4,5-T were significantly more detrimental to seedling growth at higher rates than at lower rates, whereas picloram showed no greater effects at the higher rates than at the lower rates, despite progressively lower growth as rates increased. Chlopyralid showed no statistically significant ($P \leq 0.05$) differences in its effect on plumule growth of buffalograss among rates, although slightly less growth was observed at rates of 2.2 kg/ha and greater.

Growth of blue grama seedlings was less affected by herbicides than were buffalograss and sideoats grama (Table 3). Chlopyralid had no significant influence on blue grama seedling growth, whereas the other herbicides significantly reduced plumule growth by as much as 40% in comparison to the control, at rates of 1.1 kg/ha and higher. Triclopyr, picloram, and 2,4,5-T had similar effects at comparable rates on blue grama seedlings.

Sideoats grama seedling development was reduced as herbicide rates were increased. Chlopyralid did not greatly affect seedling growth when applied at rates of 1.1 kg/ha and less. The other 3 herbicides caused significantly more damage as rate was increased, reducing plumule growth 50 to 70% of the control. Triclopyr and 2,4,5-T produced especially negative effects on growth when applied at 1.1 kg/ha or higher, while picloram at 2.2 kg/ha and higher displayed increasingly negative influences on growth (Table 3).

## Summary and Conclusions

Grass germination was affected by applications of triclopyr, 2,4,5-T, and picloram. Germination was prevented in all species by 2,4,5-T at 9.0 kg/ha, while chlopyralid did not significantly affect any species even at the highest rate. Buffalograss germination was affected by picloram and triclopyr at rates greater than 1.1 kg/ha. Blue grama germination was affected by picloram and triclopyr at rates of 4.5 kg/ha and greater. Sideoats grama germination was suppressed at 2.2 and 4.5 kg/ha when treated with picloram and triclopyr, respectively.

All herbicides influenced plumule growth, especially at higher rates. Buffalograss and sideoats grama were affected more by herbicide than was blue grama. Triclopyr, picloram, and 2,4,5-T produced significantly greater effects on plumule growth of grasses than did chlopyralid, reducing some species growth by 60%. Plumule growth of all grasses treated with chlopyralid was only slightly lower than the control treatment and did not show a significant response to application rate. Chlopyralid appears to be the most favorable herbicide of those tested for having minimal impact on grass germination and seedling growth.

The greatest reduction in plumule growth and germination occurred at herbicide rates in excess of 1.1 kg/ha. Actual damage from field application of these herbicides is doubtful because these rates exceed those recommended for brush and weed control on rangeland. Additionally, the petri dish environment probably did not allow for herbicide degradation which might occur in a field environment. It was our purpose to use formulated products, even though differences in surfactants or emulsifiers may exist and exert some influence. St. John et al. (1974) suggest that in absence of herbicides, many surfactants show marked inherent phytotoxicity at high concentrations (1% w/v) and some were growth stimulators at low concentrations (0.001% w/v). The results in this study are intended to relate to the formulated herbicides as used in the field. The comparisons made in this study do provide some indications of the relative impacts that selected herbicides used on rangeland may have on grass germination and establishment.

## Literature Cited


**Arnold, W.R. and P.W. Santelmann. 1966.** The response of native grasses and forbs to picloram. Weeds. 14:74-76.

**Baur, J.R. 1978.** Effects of picloram and tebuthiuron on establishment of ryegrass winter pastures. J. Range Manage. 31:450-455.

**Bovey, R.W., J.R. Baur, and E.C. Bashaw. 1979.** Tolerance of kleingrass to herbicides. J. Range Manage. 32:337-339.

**Bovey, R.W. and R.E. Meyer. 1981.** Effects of 2,4,5-T, triclopyr and 3,6-dichloropicolinic acid on crop seedlings. Weed Sci. 29:256-261.

**Brock, J.H., C.J. Scifres, and R.R. Hahn. 1970.** Influence of herbicides on weed control and the establishment of grasses in rangeland reseeding. Brush Research in Texas. Texas Agr. Exp. Sta. PR-2801-2828.

**Canode, C.L. 1974.** Tolerance of five cool-season perennial grasses to selected herbicides. Agron. J. 66:801-804.

**Getzendaner, M.E., J.L. Herman, and Bart van Giessen. 1969.** Residues of 4-amino-3,5,6-trichloropicolinic acid from application of Tordon herbicides. Agr. and Food Chem. 17:1251-2156.

**Lee, W.O. 1970.** Effects of picloram on production and quality of seed in several grasses. Weed Sci. 18:171-173.

**Morton, H.L., E.D. Robison, and R.E. Meyer. 1967.** Persistence of 2,4-D, 2,4,5-T, and dicamba in range forage grasses. Weeds. 15:268-271.

**Scifres, C.J. and J.C. Halifax. 1972a. Development of range grass seedlings germinated in picloram. Weed Sci. 20:341-344.**

**Scifres, C.J. and J.C. Halifax. 1972b.** Root production of seedling grasses in soil containing picloram. J. Range Manage. 25:44-46.

**Steel, R.G.D. and J.H. Torrie. 1960.** Principles and Procedures of Statistics. McGraw-Hill Book Co., New York, NY.

**St. John, J.B., P.G. Bartels, and J.L. Hilton. 1974.** Surfactant effects on isolated plant cells. Weed Sci. 22:233-237.



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