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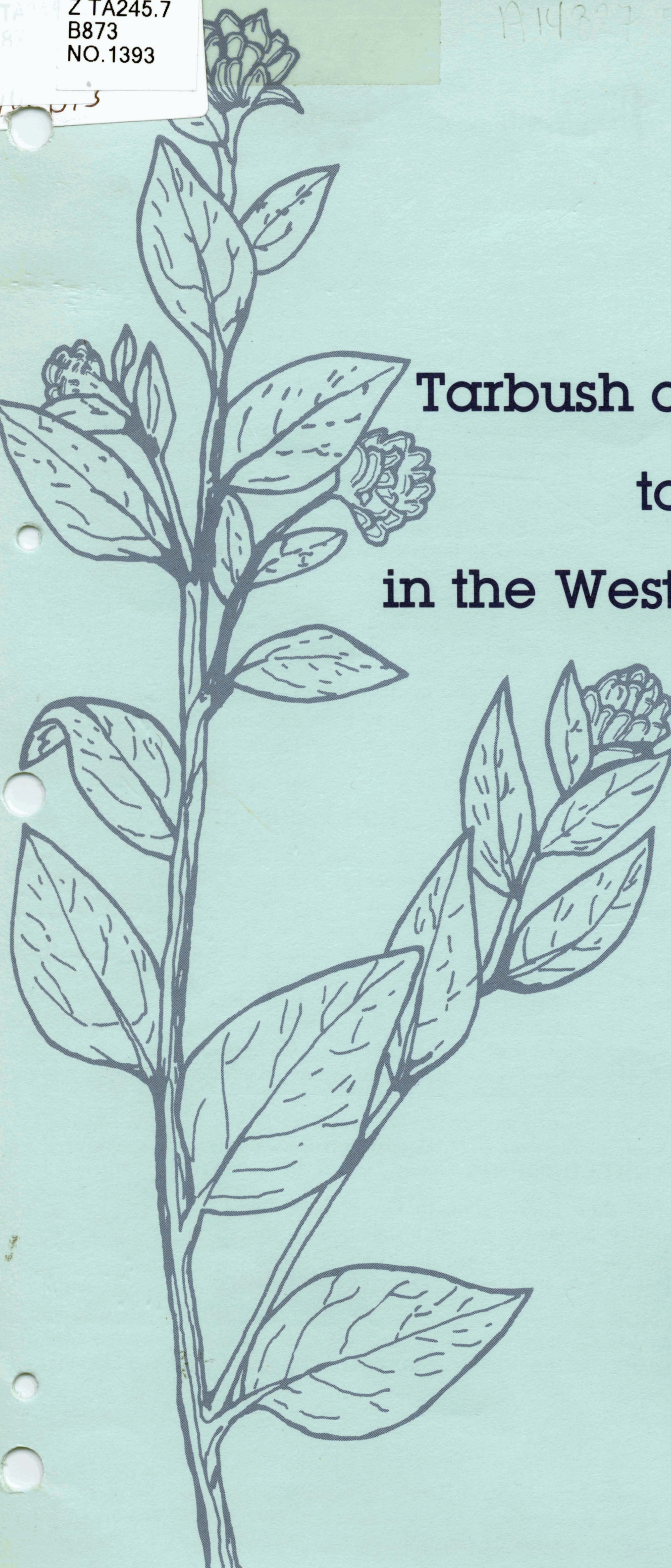

# Tarbush and Forage Response to Selected Herbicides in the Western Edwards Plateau



The Texas Agricultural Experiment Station/Neville P. Clarke, Acting Director/College Station, Texas/The Texas A&M University System

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KEYWORDS: Poisonous plants/range management/tarbush/blackbrush/tebuthiuron/picloram/pelleted herbicides.

# Tarbush and Forage Response to Selected Pelleted Herbicides in the Western Edwards Plateau

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## SUMMARY

Aerial application of 20 percent active ingredient (a.i.) tebuthiuron pellets at 0.4 kilograms per hectare (kg/ha) applied in late winter on the western Edwards Plateau killed 68 percent of the tarbush plants, while 0.8 to 1.6 kg/ha killed 95 to 99 percent. Tarbush control with tebuthiuron pellets at 0.4 to 1.6 kg/ha was not related to density of the tarbush stands. End-of-growing-season standing crop of forage was increased 81 to 158 percent during the second growing season, and 61 to 90 percent during the third growing season after application of tebuthiuron pellets at 0.8 to 1.6 kg/ha, compared to untreated rangeland. Control of 95 percent or more of the tarbush plants with tebuthiuron pellets where stand density averaged 9,441 plants/ha increased the estimated carrying capacity of the rangeland to 1 animal unit (A.U.)/25 ha during the second growing season after treatment, compared to 1 A.U./53 ha on adjacent untreated rangeland. Data from a single experiment suggest that aerial application of 5 percent a.i. picloram pellets at 0.7 kg/ha during late winter is not effective for control of tarbush.

## INTRODUCTION

Tarbush (*Flourensia cernua* DC.), also called blackbrush, infests about 5 million hectares (ha) of semiarid rangeland in the Trans Pecos, Edwards Plateau, and South Texas Plains resource areas in Texas (Smith and Rechenthin, 1964). The plant also occurs in valleys, mesas, and flats to an elevation of 1525 meters (m) in New Mexico, Arizona, and the Mexican states of Sonora, Chihuahua, Coahuila, Durango, San Luis Potośi, Zacatecas, and Mexico, D.F. (Vines, 1960). Tarbush, along with creosotebush[1], mesquite, acacia, short-lived perennial grasses, snakeweed, and burroweed develops dense, persistent stands following overgrazing and retrogression of southern desert grasslands (Weaver and Clements, 1938; Tueller, 1973). Paulsen and Ares (1962) suggested that creosotebush and tarbush are primary invaders of tobosagrass communities within southern desert grasslands, while mesquite invades black grama communities. Tarbush grows on limestone-derived soils but predominates on deep, well-drained soils (Buffington and Herbel, 1965).

Fire played a major role in preventing the establishment of many undesirable shrubs in southwestern desert grasslands prior to development of the domestic livestock industry (Wright, 1972). However, the ecological effects of fire on tarbush have not been documented (Wright, 1980). Tarbush spreads by seeds and resprouts from the crown if aerial stems are removed (Scifres, 1980).

Tarbush is generally considered unpalatable to livestock, yet sheep, goats, and cattle are frequently poisoned by consumption of tarbush when good forage is scarce (Sperry et al., 1968). The blossoms, buds, immature fruit, and ripe fruit of tarbush are poisonous. Consumption of as little as 1 percent of an animal's body weight in a day will kill some animals (Mathews, 1944).

Tarbush in New Mexico was effectively controlled by rootplowing (Abernathy and Herbel, 1973). However, successful establishment of seeded grasses on heavy loam sites was limited to areas beneath dead brush windrows, to basin pits, and to years with above-average summer rainfall (Herbel et al., 1973). Gonzales (1972) reported a 500 percent increase in forage production after seeding a tarbush-creosotebush community to blue panic grass and *Sorghum almum* in a 250-millimeter (mm) rainfall region in Chihuahua. Seeding proved successful in Chihuahua only when water catchments were built.

Tarbush is not usually susceptible to broadcast applications of phenoxy herbicides at rates commonly used on rangelands (Scifres, 1980). Schmutz (1967) reported that tarbush was most susceptible to 2,4-D ([2,4-dichlorophenoxy]acetic acid) and 2,4,5-T ([2,4,5-trichlorophenoxy]acetic acid) in August or September, about 30 days after summer rains began in the Chihuahuan Desert of Arizona. However, broadcast applications of 2,4-D and 2,4,5-T at 4.5 kg/ha in August controlled only 70 and 47 percent of the tarbush populations, respectively. Foliar sprays of picloram (4-amino-3,5,6-trichloropicolinic acid) applied with hand sprayers during summer controlled 15, 30, 55 and 85 percent of the tarbush at rates of 0.3, 0.6, 1.1, and 2.2 kg/ha, respectively.

Pelleted formulations of fenuron (1,1-dimethyl-3-phenylurea) and monuron (3-[*p*-chlorophenyl]-1,1-dimethylurea) applied at 2.2 kg/ha in summer controlled 75 and 66 percent of the tarbush, respectively, and fenuron at 4.5 kg/ha completely controlled tarbush. Monuron at 9 kg/ha killed 98 percent of the tarbush (Schmutz, 1967). Tebuthiuron (*N*-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N*,*N*′-dimethylurea) effectively controls several woody shrubs at relatively

[1]Scientific names of plants are listed in the Appendix.

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low rates (Bovey and Meyer, 1978; Scifres et al., 1979, 1981). Tebuthiuron pellets at 0.3 kg/ha have killed 90 to 95 percent of the tarbush on deep clay loam soils in southern New Mexico (C.H. Herbel, personal communication). It has been hypothesized that the efficacy of soil-active herbicides may be related to density of the target plant species as well as that of associated vegetation.

This study was conducted to determine (1) the efficacy of tebuthiuron and picloram pellets for control of tarbush, (2) whether tarbush plant density influences response to tebuthiuron, and (3) the effects of tarbush control on forage production in the western Edwards Plateau of Texas.

## MATERIALS AND METHODS

### Description of the Study Area

The experiments were located near Best, Texas in the western Edwards Plateau. Average annual precipitation is 42 centimeters (cm), which occurs mainly from April through September. Soils were Reagan silty clay loams (Ustollic Calciorthids) which consist of deep, well drained, calcareous, moderately alkaline soils formed in calcareous loamy materials. The solum thickness averages about 191 cm. A distinct accumulation of calcium carbonate occurs at 86 to 152 cm. The study area slopes 1 to 3 percent to the north.

Chemical and physical analyses of soils from the study areas were conducted from six bulk samples taken from 0 to 13-cm, 14 to 30-cm and 31 to 64-cm depths. Soil analyses included texture by the hydrometer method (Day, 1965), organic matter by the Schollenberger method (Allison, 1965), and pH measured in 0.1 M CaCl (Peech, 1965).

Soils on the Loamy range site were silty clay loams overlaying silty clay or clay subsoil (Table 1). Clay content of the surface 13 cm of soil averaged 36 percent and increased to 41-45 percent with increasing depth. Soil organic matter content averaged 2.33 percent in the upper 13 cm and decreased to 1.65 percent at the 31 to 64-cm depth. The soils were moderately alkaline (Table 1).

Dense stands of tarbush dominated the plant community on the study area. Other major woody species were honey mesquite and creosotebush. Major grasses were burrograss, threeawns and tobosagrass. Minor grass species included buffalograss, red grama, slim tridens, hairy tridens, fluffgrass, ear muhly, sand muhly, tumblegrass, plains bristlegrass, sand dropseed, Halls panicum, sideoats grama, Texas wintergrass, foxtail barley, and tumble windmillgrass. Broom snakeweed also occurred on the site.

TABLE 1. GENERALIZED SOIL CHARACTERISTICS OF RANGE SITES UTILIZED FOR EVALUATION OF TEBUTHIURON PELLETS FOR TARBUSH CONTROL ON THE WESTERN EDWARDS PLATEAU AT BEST, TEXAS

| Depth (cm) | Organic matter (%) | pH (1:1) | Textural components (%) Sand | Silt | Clay | Texture |
|---|---|---|---|---|---|---|
| | | | **1978 Experiment** | | | |
| 0-13 | 2.28 | 7.72 | 19.6 | 44.5 | 35.9 | silty clay loam |
| 14-30 | 1.97 | 7.77 | 16.1 | 40.1 | 43.8 | silty clay |
| 31-64 | 1.64 | 7.80 | 16.2 | 39.3 | 44.5 | clay |
| | | | **1979 Experiment** | | | |
| 0-13 | 2.37 | 7.77 | 19.4 | 44.5 | 36.1 | silty clay loam |
| 14-30 | 1.97 | 7.82 | 16.0 | 39.0 | 45.0 | clay |
| 31-64 | 1.65 | 7.82 | 17.2 | 41.9 | 41.0 | silty clay |

### Herbicide Applications

Herbicides including picloram pellets (5 percent a.i.) at 0.7 kg/ha and tebuthiuron pellets (20 percent a.i.) at 0.4 or 0.9 kg/ha, were aerially applied on February 14, 1978 to plots 51×402 m, arranged in a completely randomized design with two replications. Two untreated plots were randomly located among the treated plots, and 9.7-m-wide buffer strips were left between plots. Herbicides were applied with a fixed-wing aircraft in four overlapping, parallel swaths on 12.8-m centers. The aircraft was equipped with a metering plate attached to the hopper throat to regulate gravitational flow of the pelleted herbicides. A standard fertilizer spreader attached to the aircraft distributed the herbicide as the aircraft traveled at a height of 20 m.

On March 12, 1979, tebuthiuron pellets (20 percent a.i.) at 0.8 or 1.6 kg/ha were aerially applied to duplicate plots in a completely randomized design. Two untreated plots served as checks. Plot sizes and method of application were identical to those described above.

### Response of Tarbush and Associated Vegetation to Herbicide Treatments

Densities of live tarbush plants were determined in three, permanently marked, 3.05×30.5-m belt transects stratified perpendicular to the long axis of each plot prior to treatment and at 8.5, 14.5, 20 and 32 months post-treatment in the 1978 experiment; at 7 and 19 months post-treatment in the 1979 experiment. Herbicide effectiveness was based on percentage reduction in numbers of live tarbush plants in the belt transects. Response of herbaceous vegetation and broom snakeweed was determined on plots treated in March 1979. Standing crop of herbaceous vegetation and broom snakeweed was harvested in 1-$m^2$ quadrats on November 7, 1980 (20 months post-treatment) and on September 22, 1981 (30 months post-treatment). Ten quadrats, randomly located in each belt transect established for evaluation of tarbush response, were clipped (30 quadrats/plot). Plants were separated by species, except that forbs were grouped, oven-dried to constant weight, and weighed.

Data on tarbush density were subjected to arcsin $\sqrt{P}$ (P = proportion killed) transformation prior to conducting analyses of variance. Standing crop data were submitted to analysis of variance. Treatment means were separated by Duncan's multiple range tests, where appropriate. Simple linear regression techniques were used to determine the relationship between initial population density of tarbush (X) in each belt transect and ultimate mortality (Y) within each rate of tebuthiuron applied in the two experiments.

## RESULTS AND DISCUSSION

### Tarbush Control

Tarbush density on plots treated in February 1978 averaged 6,755±408 plants/ha (c.v. = 0.35). Rainfall was near normal during February 1978 (1.8 cm), but below normal during March (0.7 cm) and April (0.7 cm). Over 37 cm of precipitation fell from March through October 1978 (Table 2). Tebuthiuron pellets at 0.4 and 0.9 kg/ha had killed 46 and 86 percent of the tarbush plants, respectively, at 8.5 months after treatment (Table 3). Over 28 cm of rain fell on the study area from November 1978 through April 1979 (Table 2). By early May 1979 (14.5 months after treatment) tebuthiuron pellets had killed 63 and 97 percent of the tarbush plants at the 0.4 and 0.9 kg/ha rates, respectively (Table 3). By the end of the third growing season after treatment, tebuthiuron pellets at 0.4 and 0.9 kg/ha had killed 68 and 99 percent of the tarbush population, respectively. Picloram pellets at 0.7 kg/ha did not significantly reduce densities of live tarbush plants (Table 3).

Tarbush density on plots treated in March 1979 averaged 9,441±746 plants/ha (c.v. = 0.36). Over 13 cm of rain fell during March 1979, but precipitation was below average in April (1.7 cm) and May (4.2 cm). About 29 cm of precipitation fell from April through October 1980. Tebuthiuron pellets at 0.8 and 1.6 kg/ha had killed 90 and 94 percent of the tarbush plants, respectively, by 7 months after treatment (Table 4). Over 36 cm of precipitation fell on the study area from December 1979 through October 1980. Tebuthiuron pellets at 0.8 and 1.6 kg/ha killed 95 and 98 percent of the tarbush plants, respectively, by the end of the second growing season after treatment (Table 4).

Efficacy of tebuthiuron for control of tarbush was not related to density of tarbush in this study. Regression coefficients between tarbush density (X) and percent mortality (Y) were not significant ($P \leq 0.05$) within the tebuthiuron rates evaluated. Correlation coefficients (r) also were not significant. Density of tarbush stands within the belt transects ranged from 2,045/ha to 14,854/ha. The apparent lack of a density-dependent relationship suggests that minimum effective rates of tebuthiuron will not vary with tarbush stand density.

### Forage Response

Relatively minor localized damage to native grasses was observed during the first growing season following application of tebuthiuron pellets in 1978 and 1979, apparently caused by concentration of pellets in some areas. Phytotoxicity of tebuthiuron to native grasses during the first growing season after application has been reported by Britton and Sneva (1981) and by Scifres et al. (1981).

A pronounced increase in forage production on rangeland treated with tebuthiuron pellets was evident during the second growing season after treatment (Table 5). Average standing phytomass of grasses was 599 kg/ha

TABLE 2. MONTHLY RAINFALL DURING THE PERIOD IN WHICH PELLETED HERBICIDES WERE BEING EVALUATED FOR TARBUSH CONTROL ON THE WESTERN EDWARDS PLATEAU AT BEST, TEXAS

| | Rainfall by year (cm) | | | | |
|---|---|---|---|---|---|
| Month | 1978 | 1979 | 1980 | 1981 | 30-year average |
| January | 0.9 | 1.2 | 0.4 | 2.4 | 1.3 |
| February | 1.8 | 5.5 | 0.7 | 0.0 | 1.9 |
| March | 0.7 | 13.1 | 0.4 | 1.8 | 1.8 |
| April | 0.7 | 1.7 | 0.9 | 10.8 | 3.6 |
| May | 7.5 | 4.2 | 6.4 | 10.1 | 5.0 |
| June | 7.1 | 14.5 | 5.4 | 7.1 | 4.8 |
| July | 3.8 | 2.4 | 0.2 | 2.9 | 4.5 |
| August | 4.5 | 3.8 | 6.3 | 2.5 | 4.3 |
| September | 10.4 | 0.4 | 8.7 | 0.2 | 6.1 |
| October | 2.8 | 2.0 | 0.4 | - | 4.9 |
| November | 6.9 | 0.0 | 6.1 | - | 2.5 |
| December | 0.2 | 6.4 | 6.6 | - | 1.6 |
| Annual total | 47.3 | 55.2 | 42.5 | | 42.3 |

TABLE 3. MEAN PERCENT MORTALITY OF TARBUSH FOLLOWING AERIAL APPLICATION OF PELLETED HERBICIDES AT BEST, TEXAS IN FEBRUARY 1978

| | | Months after treatment | | | |
|---|---|---|---|---|---|
| Treatment | Rate (kg/ha) | 8.5 | 14.5 | 20 | 32 |
| None | - | 3a[1] | 8a | 0a | 10a |
| picloram (5% a.i.) | 0.7 | 3a | 6a | 1a | 17a |
| tebuthiuron (20% a.i.) | 0.4 | 46b | 63b | 63b | 68b |
| tebuthiuron (20% a.i.) | 0.9 | 86c | 97c | 97c | 99c |

[1]Means within a column followed by similar lower case letters are not significantly different at $P<0.05$.

TABLE 4. MEAN PERCENT MORTALITY OF TARBUSH FOLLOWING AERIAL APPLICATION OF TEBUTHIURON PELLETS AT BEST, TEXAS IN MARCH 1979

| | | Months after treatment | |
|---|---|---|---|
| Treatment | Rate (kg/ha) | 7 | 19 |
| None | - | 14a[1] | 7a |
| tebuthiuron (20% a.i.) | 0.8 | 90b | 95b |
| tebuthiuron (20% a.i.) | 1.6 | 94b | 98b |

[1]Means within a column followed by similar lower case letters are not significantly different at $P<0.05$.

TABLE 5. HERBACEOUS STANDING CROP (KG/HA) 20 MONTHS AFTER AERIAL APPLICATION OF TEBUTHIURON PELLETS FOR CONTROL OF TARBUSH AT BEST, TEXAS IN MARCH 1979

| | Rate (kg/ha) | | |
|---|---|---|---|
| Herbage category | 0.0 | 0.8 | 1.6 |
| Burrograss | 128a[1] | 133a | 229b |
| Threeawns | 98a | 323b | 416c |
| Tobosagrass | 81a | 66a | 133a |
| Other grasses | 24a | 77b | 76b |
| Total Grasses | 331a | 599b | 854c |
| Forbs | 14b | 6a | 6a |
| Broom snakeweed | 1a | 0a | 3a |

[1]Means within a row followed by similar lower case letters are not significantly different at $P<0.10$.

and 854 kg/ha on rangeland treated with tebuthiuron pellets at 0.8 and 1.6 kg/ha, respectively, compared to 331 kg/ha on adjacent untreated rangeland (Table 5). Standing crop of burrograss (229 kg/ha) was significantly higher on plots treated with tebuthiuron pellets at 1.6 kg/ha, compared to untreated rangeland (128 kg/ha) and rangeland treated with the low rate of tebuthiuron (133 kg/ha). Standing crop of threeawns was also greater on plots treated with the high rate of tebuthiuron pellets (416 kg/ha), compared to the low rate (323 kg/ha), and standing crop of threeawns on plots treated with tebuthiuron pellets at the low rate was significantly higher than that on untreated rangeland (98 kg/ha). Neither the autumn crop of forbs nor broom snakeweed was affected by tebuthiuron at the rates evaluated (Table 5).

Control of 95 percent or more of the tarbush plants where stand density averaged 9,441 plants/ha increased perennial grass production 268 to 523 kg/ha during the second growing season after treatment, compared to adjacent untreated rangeland. Assuming that only 25 percent of the total available herbage will be utilized by livestock (the remainder being consumed by other herbivores, left as standing dead material, deposited as litter, lost to trampling, or contaminated with dung), and that an animal unit (A.U.) requires 12.02 kg of forage (dry weight) per day, 95 percent or greater control of tarbush more than doubled the estimated carrying capacity of this tarbush-dominated semiarid rangeland. During the second growing season after treatment, carrying capacity rose from 1 A.U./53 ha to 1 A.U./25 ha (average for rangeland treated with tebuthiuron pellets at 0.8 and 1.6 kg/ha).

Standing phytomass of threeawns and forbs on rangeland treated with tebuthiuron pellets was significantly higher than on untreated rangeland at the end of the third growing season after treatment (Table 6). The standing crops of burrograss, tobosagrass and minor species were not affected by the tebuthiuron treatments. Standing crop of threeawns on untreated rangeland was only 315 kg/ha, compared to 1074 kg/ha and 911 kg/ha on rangeland treated with tebuthiuron pellets at 0.8 and 1.6 kg/ha, respectively (Table 6). Threeawns comprised about 28 percent of the standing phytomass on untreated rangeland, compared to 60 and 43 percent on plots treated with tebuthiuron pellets at the low and high rates, respectively. Standing phytomass of annual forbs was 126 to 182 percent greater on tebuthiuron-treated rangeland than on adjacent untreated rangeland. Broom snakeweed was significantly reduced on tebuthiuron-treated plots (Table 6).

Production of grasses and forbs on rangeland treated with tebuthiuron pellets was increased 678 to 1,006 kg/ha during the third growing season after treatment, compared to tarbush-dominated rangeland. Estimated carrying capacity was 1 A.U./15.7 ha on untreated rangeland during the third growing season post-treatment, compared to 1 A.U./9 ha on rangeland treated with tebuthiuron pellets (average for 0.8 and 1.6 kg/ha rates).

TABLE 6. HERBACEOUS STANDING CROP (KG/HA) 30 MONTHS AFTER AERIAL APPLICATION OF TEBUTHIURON PELLETS FOR CONTROL OF TARBUSH AT BEST, TEXAS IN MARCH 1979

| Herbage category | Rate (kg/ha) 0.0 | 0.8 | 1.6 |
|---|---|---|---|
| Burrograss | 376a[1] | 226a | 360a |
| Threeawns | 315a | 1074b | 911b |
| Tobosagrass | 235a | 66a | 314a |
| Other grasses | 24a | 47a | 63a |
| Total Grasses | 950a | 1413ab | 1648b |
| Forbs | 170a | 385b | 479b |
| Broom snakeweed | 17b | 1a | 0a |

[1]Means within a row followed by similar lower case letters are not significantly different at P<0.05.

## CONCLUSIONS

Tebuthiuron 20 percent (a.i.) pellets applied in late winter at 0.4 to 1.6 kg/ha effectively controlled tarbush growing on silty clay loam soils in the western Edwards Plateau, whereas picloram 10 percent (a.i.) pellets did not reduce densities of tarbush. Tarbush refoliated several times during the first growing season after treatment with tebuthiuron pellets, but most of the phytotoxic effects were manifested within a year after treatment.

The efficacy of tebuthiuron pellets at rates of 0.4 to 1.6 kg/ha for tarbush control was not related to densities of tarbush stands in the range from 2,000 to 15,000 plants/ha. The apparent lack of a density-dependent relationship suggests that minimum effective rates of tebuthiuron will not vary with density of tarbush stands.

Native grasses were damaged during the first growing season after applications of tebuthiuron pellets. However, end-of-growing-season standing crops of forage were increased 81 to 158 percent during the second growing season and 61 to 90 percent during the third growing season on rangeland treated with tebuthiuron, compared to adjacent untreated rangeland. Threeawns increased in importance on rangeland treated with tebuthiuron, apparently indicating the tolerance of the genus *Aristida* to tebuthiuron and its ability to use soil water released by removal of competing shrubs. Native forb standing crops were two to three times greater during the third growing season after tebuthiuron applications, compared to those on tarbush-dominated rangeland.

## LITERATURE CITED

Abernathy, G. H. and C. H. Herbel. 1973. Brush eradicating, basin pitting, and seeding machine for arid to semiarid rangeland. J. Range Manage. 26:189-192.

Allison, L. E. 1965. Organic carbon. *In* C. A. Black (Ed) Methods of soil analysis. (Part II). Amer. Soc. Agron., Madison, Wis. p. 1367-1378.

Bovey, R. W. and R. E. Meyer. 1978. Control of huisache with soil applied herbicides. J. Range Manage. 31:179-182.

Britton, C. M. and F. A. Sneva. 1981. Effects of tebuthiuron on western juniper. J. Range Manage. 34:30-32.

Buffington, L. C. and C. H. Herbel. 1965. Vegetation changes on a semi-desert grassland range from 1858 to 1963. Ecol. Monogr. 35:139-164.

Day, P. R. 1965. Particle fractionation and particle size analysis. *In* C. A. Black (Ed) Methods of soil analysis. (Part I). Amer. Soc. Agron., Madison, Wis. p. 545-567.

Gonzales, M. H. 1972. Manipulating shrub-grass plant communities in arid zones for increased animal production, p. 425 to 434. *In* C. M. McKell, J. P. Blaisdell and J. R. Goodin (Ed) Wildland shrubs — their biology and utilization. U.S. Dept. Agr. Forest Service Gen. Tech. Rep. INT-1.

Herbel, C. H., G. H. Abernathy, C. C. Yarbrough, and D. K. Gardner. 1973. Rootplowing and seeding arid rangelands in the Southwest. J. Range Manage. 23:193-197.

Mathews, F. P. 1944. The toxicity of the ripe fruit of blackbrush for sheep and goats. Texas Agr. Exp. Sta. Bull. 664. 16 p.

Paulsen, H. A., Jr. and F. N. Ares. 1962. Grazing values and management of black grama and tobosa grasslands and associated shrub ranges of the Southwest. U.S. Dept. Agr. Tech. Bull. 1270. 56 p.

Peech, M. 1965. Hydrogen ion activity. *In* C. A. Black (Ed) Methods of soil analysis. (Part II). Amer. Soc. Agron., Madison, Wis. p. 914-926.

Schmutz, E. M. 1967. Chemical control of three Chihuahuan Desert shrubs. Weed Sci. 15:62-67.

Scifres, C. J. 1980. Brush Management-Principles and Practices for Texas and the Southwest. Texas A&M University Press. College Station, Texas. 360 p.

Scifres, C. J., J. L. Mutz, and W. T. Hamilton. 1979. Control of mixed brush with tebuthiuron. J. Range Manage. 32:155-158.

Scifres, C. J., D. L. Embry and J. L. Mutz. 1981. Whitebrush response to tebuthiuron and picloram pellets. Texas Agr. Exp. Sta. Bull. 1356. 10 p.

Scifres, C. J., J. W. Stuth and R. W. Bovey. 1981. Control of oaks (*Quercus* spp.) and associated woody species on rangeland with tebuthiuron. Weed Sci. 29:270-275.

Scifres, C. J., J. W. Stuth, D. R. Kirby and R. F. Angell. 1981. Forage and livestock production following oak (*Quercus* spp.) control with tebuthiuron. Weed Sci. 29:535-539.

Smith, H. N. and C. A. Rechenthin. 1964. Grassland restoration — the Texas brush problem. U.S. Dept. Agr., Soil Conservation Service, Temple, Texas. 33 p.

Sperry, O. E., J. W. Dollahite, G. O. Hoffman, and B. J. Camp. 1968. Texas plants poisonous to livestock. Texas Agr. Exp. Sta. Bull. 1028. 59 p.

Tueller, P. T. 1973. Secondary succession, disclimax, and range condition standards in desert shrub vegetation. *In* D. N. Hyder (Ed) Arid shrublands-Proceedings of the third workshop of the United States/Australia Rangelands Panel. Soc. Range Manage. Denver, Colo. p. 57-65.

Vines, R. A. 1960. Trees, Shrubs and Woody Vines of the Southwest. University of Texas Press, Austin, Texas. 1104 p.

Weaver, J. E. and F. E. Clements. 1938. Plant Ecology. McGraw-Hill Book Co. New York. 601 p.

Wright, H. A. 1972. Shrub response to fire, p.204 to 217. *In* C. M. McKell, J. P. Blaisdell and J. R. Goodin (Ed) Wildland shrubs — their biology and utilization. U.S. Dept. Agr. Forest Service Gen. Tech. Rept. INT-1.

Wright, H. A. 1980. The role and use of fire in the semidesert grass-shrub type. U.S. Dept. Agr. Forest Service Gen. Tech. Rept. INT-85. 24 p.

## Metric Units — English Equivalents

| Metric Unit | English Equivalent |
|---|---|
| Centimeter (cm) | 0.394 inch |
| Hectare (ha) | 2.47 acres |
| Kilogram (kg) | 2.205 pounds |
| Kilogram per hectare (kg/ha) | 0.892 pound per acre |
| Meter (m) | 3.28 feet |
| Millimeter (mm) | 0.0394 inch |
| Square meter ($m^2$) | 10.758 square feet |

## APPENDIX

### Scientific Names of Plants Mentioned in Text

| Common Name | Scientific Name |
|---|---|
| Acacia | *Acacia* spp. |
| Black grama | *Bouteloua eriopoda* |
| Blue panic grass | *Panicum antidotale* |
| Broom snakeweed | *Xanthocephalum sarothrae* |
| Buffalograss | *Buchloe dactyloides* |
| Burrograss | *Scleropogon brevifolius* |
| Burroweed | *Happlopappus tenuisectus* |
| Creosotebush | *Larrea tridentata* |
| Ear muhly | *Muhlenbergia arenacea* |
| Foxtail barley | *Hordeum jubatum* |
| Fluffgrass | *Erioneuron pulchellum* |
| Hairy tridens | *Erioneuron pilosum* |
| Halls panicum | *Panicum hallii* |
| Honey mesquite | *Prosopis glandulosa* Torr. var. *glandulosa* |
| Mesquite | *Prosopis* spp. |
| Plains bristlegrass | *Setaria leucopila* |
| Red grama | *Bouteloua trifida* |
| Sand dropseed | *Sporobolus cryptandrus* |
| Sand muhly | *Muhlenbergia arenicola* |
| Sideoats grama | *Bouteloua curtipendula* |
| Slim tridens | *Tridens muticus* |
| Snakeweed | *Xanthocephalum* spp. |
| Texas wintergrass | *Stipa leucotricha* |
| Threeawns | *Aristida* spp. |
| Tobosagrass | *Hilaria mutica* |
| Tumblegrass | *Schedonnardus paniculatus* |
| Tumble windmillgrass | *Chloris verticillata* |


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