Proceedings Western Society of Weed Science 37:113-127

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Tebuthiuron Residues in Chihuahuan and Sonoran Desert Soils[1]

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Abstract:Plots were treated with pellets containing 20% a.i. of tebuthiuron N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2yl]-N-N[1]-dimethyurea), during the spring of 1981 and 1982 at three sites located in the Chihuahuah desert in the state of Chihuahua, Mexico and one site located in the Sonoran desert in the state of Arizona, United States of America. Three rates of tebuthiuron 0.5, 1.0, and 1.5 kg a.i./ha were applied. Soils were sampled at 0-2, 2-10, and 10-20 cm at 6, 12, 18 and 24 months after application and analyzed for tebuthiuron resideus using gas chromatography. Tebuthiuron concentrations were different between sites, years and soil depths. When all depths and sites were combined using weighted averages, tebuthiuron concentrations in the top 20 cm were 0.11, 0.10, and 0.04 ppm, after 12, 18, and 24 months, respectively, on plots treated at 1.5 kg a.i./ha were 0.32, 0.26, and 0.16 ppm after 12, 18. 24 months, respectively. Amount and distribution of precipitation, organic matter and silt content seem to influence tebuthiuron persistence in the soils.

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INTRODUCTION

Tebuthiuron is an effective substituted urea herbicide for total vegetation control (18) and for the control of certain brush species on rangeland of the Southwestern United States (12,13,14,15,16).

Since tebuthiuron was introduced for brush control on rangelands many research studies have been done to determine the physiological effects of tebuthiuron in different species. Also parameters such as rates formaulations and time of application have been tested to improved brush control effectiveness. Several investigations have been conducted to determine the persistence of tebuthiuron residues in rangeland soils of the South and Southwest United States (3,4,6); However, only a few studies have been conducted on persistence of tebuthiuron residues in desert soil (3,7).

Since tebuthiuron is a soil applied herbicide which is absorbed by the roots of plants, its concentration, persistence and movement in the soil are developing selective control measures for brush species in forage producing rangelands.

Bouwy, et al. (3) and Baur (2), indicate that the long life of tebuthiuron makes it a useful product in brush control but the persistence in soils may inhibit the growth of desirable vegetation and presents the establishment of seedlings. Forb production and density have decreased when 1 kg/ha or more of tebuthiuron was applied; However, Forb cover has recovered to orginal levels after 3 years (15).

Organic matter and silt content are two very important factors controlling the mobility of soil applied substituted urea herbicides in soils. The organic matter concentrated in the surface absorbes

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the herbicide 2nd prevents its leaching into lower levels. However, the herbicide seems to dissipate more rapidly in the surface layer primarily because content to organic matter and rates of microbial degradation are higher at the soil surface (5). Organic matter may be responsible for absorption or herbicide in some soils and clay may be more important in others. The single most important variable regulating response of a susceptible species to tebuthiuron is the application rate (8,10). Tebuthiuron is metabolized in the soil by microorganisms and absorbed by the roots of higher plants (1,18). Chang and Stritzbe (6) showed that greater dissipation occured at 15% soil moisture and 30°C than lower temperatures or lower moisture levels. Vertical mobility of tebuthiuron decreases as organic matter, cation exchange capacity and clay content increases (5,6,9).

The objective of this study was to determine the level of residues of tebuthiuron at four rangeland sites over time.

MATERIALS AND METHODS

Locations in the chihuahuan desert were Rancho La Reforma at Allende, Chihuahua, Mexico, at an elevation of 1500 M, with an average precipitation of 400 mm and a mean annual temperature of 17.5°C. The major brush species are whitethorn (*Acacia constricta* Benth.), tarbush (*Floutensia cernua* DC.), creosotebush [*Larrea tridentata* (DC.) Coville] and shrubby senna (*Cassia Wislizeni* Gray). The major grass species are spike papusgrass (*Eneapogon desvauxii*), fluffgrass [*Tridens pulchellus* (H.B.K.) Hitchc.] and blackgrama (*Boutelova eriopoda* Torr.). Rancho Los Pozos at Aldama Chichuahua, Mexico, at an elevation of 1400 masl, with an average precipitation of 253 mm and with a mean annual temperature of 17.9°C. The major brush species are tebush, mariola (*Parthenium incanum* H.B.K.), whitethorn and tarbush. The major grass species are fluffgrass, threeawn (*Aristida* spp.) and spike pappusgrass. Rancho El Toro at Villa Ahumada Chichuahua, Mexico, at an elevation of 1380 M, with an average precipitation of 270 mm and with a mean annual temperature of 17.5°C. The major brush species are creosotebush, whitethorn, and mesquite [*Prosopis juliflora* (Swartz) DC]. The major grass species are black grama, fluffgrass and bushmuhly (*Muhlenbergia porteri* Scribn.). Santa Rita Experimental Range at Tucson, Arizona, at an elevation of 968 M, with an average precipitation of 290 mm and a mean annual temperature of 19.°C. The major brush species are creosotebush, zinnia (*Zinnia pumila* Gray),and velvet (*Piulifora var. velutina*) mesquite. Major grass species are fluffgrass, bushmuhly and *Aristida* spp.

Soils of the study site were characterized relative to textural components by the hydrometer method; Organic matter content by acid digestion and titration; Ph of 1:2, soil water slurries and electrical conductivity of saturated paste (Table 1).

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Triplicated plots wee hand broadcasted with Tebuthiuron pellets (3.2mm diameter by 5 mm long) containing 20% a.i. at rates of 0.5, 1.0 and 1.5 Kg oil ha during 1981 and 1982. Soils were sampled, 6, 12, 18 and 24 months after tebuthiuron application. Samples were collectd from 10 holes dug by hand at 10-m interals diagonally removed from the sides of the holes at 0°2, 2 to 10 and 10 to 20 cm depths. Samples from each depth were combined into one sample, this made a total of one sample for each depth and a total of three samples on each plot. Prior to analysis soils were air dried and separated into fractions larger than 2 mm and smaller than 2 mm. The fraction smaller than 2 mm, was thoroughly mixed and a zogs subsample was taken for analysis of tebuthiuron and its metabolites.

Tebuthiuron soil residues were determined by following the method modified slightly from that developed by Loh et al (11). Tebuthiuron was extracted from soil samples by refluxing in a mixture of methanol and hydrochloric acid. Tebuthiuron residues was transferred from the extract into ethyl acetate by liquid-liquid partition. Samples were evaporated and reconstituted with a mixture of Acetronitrile and Isopropanol, and then passed through an alumina column in order to remove organic contaminant materials. Tebuthiuron residues were extracted from the column with Acetronitrile and isopropanol. Tebuthiuron residues were evaporated and reconstituted with pure Acetonitrile. Finally, samples were quantified for tebuthiuron by gas chromatography with flame photometric detection.

Treatments at all locations were arranged in a randomized complete block design and replicated three times on 0.5 ha plots (100x 50 m).

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Concentration means for each location treated with the same rate of herbicide were graphed at each date of sampling. Then location means were analysed at each date of sampling obtaining a total mean for all locations. Regression equations were developed in order to determine when the concentrations of tebuthiuron applied at each rate reached undetectable levels. Data was subjected to analysis of variance and when significant (PL 0.05) differences were detected, residue means were componed using Duncan's Multiple Range Test (17).

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RESULTS AND DISCUSSION

Amount and distribution of precipitation was very variable between locations in 1981 and 1982. At Rancho La Reforma precipitation was below average during both 1981 and 1982. At Rancho Los Pozos and Rancho El Toro precipitation was average in 1981 and below average in 1982. At Santa Rite Experimental Range summer precipitation was below average in 1981 and above average in 1982, but winter precipitation was above average in both 1981 and 1982.

Results indicate a highly significant difference between treatment rates at all locations. Concentrations were usually greater in soils treated with 1.5 Kg ai/ha than with 1.0 and 0.5 Kg ai/ha application rates. Tebuthiuron residues were significantly different between locations only at 6 mohths for the 1.0 kg/ha rate and at 12 months after application for all rates of tebuthiuron application. Tebuthiuron persisted on treated plots at all locations regardless of the amount of precipitation even 24 months after herbicide application. Tebuthiuron concentration means across locations on the top 20 cm of soil 24 months after application ranged from 0.021 to 0.052 mg/g on the 0.5 Kg ai/ha treated plots, from 0.073 to 0.172 Mg/g on the 1.0 Kg ai/ha treated plots and from 0.132 to 0.203 Mg/g on the 1.5 Kg ai/ha treated plots (Table 2). Generally tebuthiuron tended to move deeper into the soil over time. Tebuthiuron concentration on the top 2 cm was present in significant quantities only at La Reforma and El Toro 12 months after tebuthiuron application at rate of 0.5 Kg ai/ha, but disappeared almost completely after 18 months at all the locations (Figure 1). After 18 months most of the tebuthiuron was disipated into the 2-10 and 10-20 cm depth. Tebuthiuron residues persisted longer on the 2-10 and 10 to 20 cm depth and significant levels were still presents on the soil at La Reforma and El Toro 24 months after tebuthiuron application.

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Tebuthiuron residues on the top 2 cm were greater 24 months after application on plots treated with 1.0 kg ai/ha then on plots treated with 0.5 Kg ai/ha (Figure 2). Greater tebuthiuron residues were found on the top 2 cm of soil on the sites with less precipitation. Significant levels of tebuthiuron were present on the top 2 cm 18 months after application in all locations; However, only at La Reforma were significant levels detected 24 months after application. Most of the tebuthiuron residues were moved to the 2-10 and 10-20 cm in depths 18 months after tebuthiuron application. The greatest soil residence were found at La Reforma at all soil depths 24 months after tebuthiuron applications. Very similar tebuthiuron disipation patterns were obtained on plots treated with 1.5 Kg ai/ha rate, but high concentrations were detected at all depths our time compared with 0.5 and 1.0 Kg ai/ha rates (Figure 3). Tebuthiuron residues were very well distrubuted across all soil depths during the first 12 months following herbicide application. However, 6 and 12 months after tebuthiuron residues disipated from the top 2 cm of soil and soil residues were greater at 2-10 and 10-20 cm soil depths.

Data indicate that significant levels of tebuthiuron persist in the soil 24 months following herbicide application. Even so, a high percent of brush mortality has been achived, remaining shrub and grasses have not removed all herbicide from the top 20 cm, even though some herbicides seem to be already disipataed into deeper soil.

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Greater levels of tebuthiuron were detected at La Reforma under all rates applied compared with the other locations. The higher organic matter content in soils at La Reforma may be reducing tebuthiuron dissipation to some degree. However, low precipitation occurred and the slightly higher silt content in the soil may also account for the slower tebuthiuron disipation compared with the other locations.

Amount of precipitation following tebuthiuron application seems to influenciate directly herbicide disipation in desert soils, but precipitation during the first 18 months folowing herbicide application seems to amount of rate variations in tebuthiuron residues between locations. Tebuthiuron residues after the second rainy season were very similar between locations at plots treated at the same rate regardless of precipitation.

Significant ($P \leq 0.05$) regression equations were obtained with the application of both 0.5, 1.0 and 1.5 Kg ai/ha when time (months) was regressed against tebuthiuron concentration (Figures 4, 5, anfd 6). Twenty-three, 32, and 32% of tebuthiuron was still present in the top 20 cm. Twenty-four months after applicaiton of 0.5, 1.0, and 1.5 Kg/ha respectively. Using these equations it will take 31.5, 34, and 37 months for concentrations of tebuthiuron to reach undetectable levels after the application of 0.5, 1.0 and 1.5 Kg/ha, respectively. These results similate those found by Emmerick et al (7) in Tombstone, Arizona after the application of 0.84 Kg/ha of tebuthiuron in a watershed, they predict through a liner reg eq. 2.9 years (34.8 months) for almost complete dissipation of tebuthiuron in the top 15 cm of soil.

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A significant regression equation was also obtained when we graphed the rate of tebuthiuron aplied versus the expected time of tebuthiuron disappearance (Figure 7). With this equation we can predict very closely the time of tebuthiuron disappearance from the top 20 cm of soil for given rates of tebuthiuron application.

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CONCLUSIONS

The residual life of tebuthiuron in desert soils makes it a highly useful herbicide for brush control. The highest residue levels after 24 months were found in the soils with the highest organic matter and clay contents. These results suggest that tebuthiuron may be tied up by the organic matter and absorbed on the clay resulting in slower dissipation than from soils with low organic matter and clay contents. When applied over a wide range of soil and vegetation types tebuthiuron dissipated from semiacre rangeland soils in approximately 3.0 years when applied for woody plant control.

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Table 1. Physical and chemical properties of 3 Chihuahuan and 1 Sonoran Desert Soils.

Locations	% Soil Particles < 2 mm	% Soil Particles > 2 mm	Sand	% Silt	Clay	Texture Class	O.M.%	PH	EC Mmhos/am
La Reforma	55	45	59	26	15	Sandy Loam	3.6	6.9	2.9
Los Pozoa	71	29	60	29	11	Sandy Loam	1.5	7.2	1.3
El Toro	77	23	66	24	10	Sandy Loam	1.1	7.9	1.1
SRER	83	17	58	28	11	Sandy Loam	0.7	7.9	1.1

Table 2. Tebuthiuron residues Mg/g of soil (Weight average) over time in the top 20 cm of soil after herbicide application at rates of 0.5, 1.0 and 1.5 Kg ai/ha at four desert soils.

Time after Treatment (Months)	La Reforma	Los Pozos	El Toro	SRES	Date mean
	(0.5 Kg ai/ha)				
6	-----	-----	-----	-----	-----
12	0.150	0.099	0.166	0.042	0.114
18	0.077	0.101	0.158	0.043	0.095
24	0.059	0.021	0.045	0.032	0.039
	(1.0 Kg ai/ha)				
6	0.502	0.308	0.124	-----	0.311
12	0.178	0.410	0.198	0.163	0.237
18	0.110	0.188	0.200	0.153	0.163
24	0.171	0.101	0.071	0.095	0.110
	(1.5 Kg ai/ha)				
6	-----	-----	-----	-----	-----
12	0.161	0.450	0.286	0.395	0.323
18	0.156	0.217	0.429	0.255	0.264
24	0.204	0.137	0.165	0.151	0.164