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Triclopyr Persistence in Northern Idaho Forest Vegetation

Steven G. Whisenant[1] and E. Durant McArthur[2]

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602, USA and [2]U.S. Forest Service, Intermountain Research Station, Shrub Sciences Laboratory, 735 North 500 East, Provo, Utah 84601, USA

Triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid) is increasingly becoming important for woody plant control (Boyd *et al.* 1985) in the inland Pacific Northwest. Current registration allows the use of triclopyr in site preparation, conifer release and vegetation control on rights-of-way. Norris *et al.* (1987) determined the movement and persistence of triclopyr in grass, soil, and water of a western Oregon hill-pasture, but no data are available on triclopyr persistence in the inland, Pacific Northwest.

The intake of significant amounts of herbicide, by terrestrial animals is most likely to result from consumption of recently treated vegetation (Norris 1977). Elk, deer, cattle, and horses may be exposed to triclopyr used for brush control along rights-of-way, fence rows, or in forested areas sprayed for conifer release or site preparation. Feeding studies in rats and mice established the no observable effect level at 30 mg kg^{-1} body wt (Weed Science Society of America 1983).

Our objectives were to determine persistence of triclopyr in the forage at two northern Idaho sites. Triclopyr residues in terminal twig and leaf segments were examined for 12 mon after application of 2.3 kg ae triclopyr ha^{-1}. Such information should be useful in determining the potential for poisoning and in determining if triclopyr may reasonably be used where elk, deer, cattle, and horses are present.

MATERIALS AND METHODS

Two sites near Bovill, Idaho were selected as study sites. Four 9.2- by 23-m plots were marked at each site. Site 1 had a southwest exposure averaging 31% slope and was dominated by shinyleaf ceanothus (*Ceanothus velutinus* Dougl. ex. Hook.) (88% cover with plants averaging 0.96 m high). The soil on this site was a silt (medial over loamy-skeletal mixed, frigid Typic Vitrandpt). Douglas fir [*Pseudotsuga menziesii* (Mirbel)Franco] plants averaged 0.48 m high.

[1]Send reprint requests to S. G. Whisenant at Dept. Range Science, Texas A&M University, College Station, TX 77843-2126.

Site 2 had a northeast exposure averaging 10% slope, with a silt loam soil (medial over loamy-skeletal mixed, frigid Typic Vitrandpt). Only about 9% of the site was covered with shinyleaf ceanothus and few Douglas fir plants were overtopped. Site 2 had additional species, such as Wood's rose (*Rosa woodsii* Lindl), sticky currant (*Ribes viscosissimum* Pursh), mountain lover [*Pachistima myrsinites* (Pursh) Raf.] and snowberry [*Symphoricarpos albus* (L.) Blake].

The butoxyethyl ester of triclopyr (2.3 kg ae ha^{-1} with 1.2 L polyglycol surfactant, 2.3 L ha^{-1} of diesel oil, and enough water to give 93.5 L ha^{-1} total solution) was applied to four plots at both study sites on 10 August 1986. Site 1 was treated at 24C and 38% relative humidity. Site 2 was treated at 28C and 31% relative humidity. The herbicide mixture was applied with a backpack sprayer. The spray was applied with a single nozzle at 3.2 m above ground and a 9.2 m swath width.

The study was designed as a completely randomized experiment. Triclopyr residues were analyzed as a factorial with species and time after application as the factors, these data were analyzed by site.

Terminal branch and leaf samples were collected at 1, 6, 28, 76, 277, and 365 d after application of triclopyr. Samples were frozen after collection and kept frozen until extraction and analysis. Foliage and the terminal 15 cm of stems were collected. Grass foliage samples were clipped to ground level. These foliage samples represent the most likely sources of food for large herbivores. Two subsamples of each species were collected at each of the four plots per site. Composite foliage samples were prepared in the laboratory by combining equal amounts of material from the two subsamples.

Triclopyr was extracted from foliage samples by blending the leaf material in a 7:1 mixture of acidified acetone water for 3 minutes. The mixture was then filtered and reduced in volume prior to adjusting pH to 8.0–8.5 with $NaHCO_3$. The triclopyr was next extracted from the acetone with 2 liquid-liquid separations in hexane. The mixture was then reduced in volume and methylated with BF_3-methanol prior to analysis with a gas chromatograph by the McKellar method (McKellar, R. L. 1977. Determination of triclopyr; 3,5,6-trichloro-2-pyridinol and 2-methoxy-3,5,6-trichloropyridine in soil by gas chromatography. ACR 77.5. Dow Chemical Co. Midland, MI. 23 p.). Triclopyr recovery from fortified foliage samples averaged 89% for Douglas fir, 87% for shinyleaf ceanothus, 92% for Wood's

rose, 93% for grasses, 90% for mountain lover, and 94% for snowberry at 0.1 $\mu g\ g^{-1}$.

RESULTS AND DISCUSSION

Triclopyr concentrations in the foliage varied among species at both sites. One d after application, the highest concentration, 362 $\mu g\ g^{-1}$, occurred in shinyleaf ceanothus on the southwest slope (Table 1). Shinyleaf ceanothus foliage had the highest triclopyr concentrations, possibly because the broad leaves intercepted more spray material. Based on the average for all species at d 1, a 42% decline occurred after 6 d, 72% in 28 d, and more than 98% 365 d after application. The lowest initial concentration occurred in Wood's rose on the northeast slope (Table 1). Wood's rose, sticky current, and snowberry were killed by the herbicide application. Thus, no foliage of those species was available after the 28 d collection period. Shinyleaf ceanothus samples collected 277 and 365 d after treatment contained only dead leaves which had not dropped.

Mean herbicide concentrations were markedly different among species and sampling time. There was a highly significant species by sampling time interaction at each site, indicating the rate of change in triclopyr concentration differed among species. Dead leaves which dropped from the plant were not included in the samples.

The change in triclopyr concentration in all species (combined) was best explained by the equation: $Y = 242(\text{d after application})^{-0.696}$, where Y is the triclopyr concentration in mg g^{-1}, (r^2=0.69). Regression equations for triclopyr disappearance in the individual species explained 83 to 97% of the variation using a single independent variable, time (d) after application (Table 2). Residue levels observed at a specific point in time are the result of several processes, all of which may proceed at different rates. Processes such as volatilization, washing off from rainfall, and translocation may predominate shortly after application, while weathering, root exudation, and metabolism may be more important later (Norris *et al.* 1984).

A 450 kg cow that consumed 11.0 kg of shinyleaf ceanothus leaves (100% of total consumption) in the treated area, one d following application would receive about 8.8 mg triclopyr kg^{-1} body wt. A 60 kg whitetail deer in the treated area that consumed 1.5 kg of shinyleaf ceanothus leaves (100% of total consumption) one d following application would receive about 9.0 mg triclopyr kg^{-1} body wt. This

Table 1. Triclopyr levels in terminal branch and leaf segments following application of 2.3 kg triclopyr ha^{-1} to a southwest slope near Bovill, Idaho.

Species	Days after Applications					
	1	6	28	76	277	365
	($\mu g\ g^{-1}$)					
	Southwest slope					
Shinyleaf ceanothus	362.6 ± 243.9	253.7 ± 106.8	96.2 ± 8.6	46.1 ± 7.0	24.5 ± 8.6	4.7 ± 0.7
Douglas fir	198.9 ± 160.5	81.5 ± 13.4	9.4 ± 3.4	7.6 ± 2.6	3.3 ± 1.5	1.2 ± 0.8
	Northeast slope					
Shinyleaf ceanothus	354.7 ± 207.2	249.9 ± 32.6	187.0 ± 41.3	74.1 ± 20.0	25.7 ± 5.8	6.7 ± 1.1
Douglas fir	151.4 ± 29.5	58.0 ± 36.8	20.3 ± 7.0	6.7 ± 1.8	2.4 ± 0.8	1.5 ± 0.4
Mountain lover	176.3 ± 70.3	75.0 ± 40.6	32.3 ± 4.4	15.3 ± 8.1	7.6 ± 3.0	2.6 ± 0.8
Woods rose	79.1 ± 21.0	49.7 ± 2.8	33.2 ± 3.1	-----	-----	-----
Sticky currant	100.4 ± 23.6	68.6 ± 11.8	35.7 ± 1.3	-----	-----	-----
Snowberry	108.6 ± 19.9	81.5 ± 7.7	49.9 ± 18.9	-----	-----	-----
Grasses	156.7 ± 45.2	53.6 ± 14.7	11.4 ± 4.0	4.7 ± 1.3	1.2 ± 0.5	0.2 ± 0.1

'worst-case' scenario is unlikely since shinyleaf ceanothus is not a desired forage species. A diet study conducted in the Chopaka Mountains of Washington (Campbell and Johnson 1983) indicated that during the summer, shinyleaf ceanothus comprised only 3.1 and 0.6% of mule deer and cattle diets, respectively.

Dosing cattle with 150 mg triclopyr kg^{-1} body wt resulted in mortality after 6 d dosing (Rowe 1980). No data are available on the "No Observable Effect Level" of cattle, deer, or elk. Ponies dosed at 60 mg kg^{-1} body wt had no significant clinical effects or lesions. For ponies, 300 mg kg^{-1} body wt appears to be an approximate multiple dose LD_{50}. The toxic usage in ponies was 5 times the estimated maximal intake for the highest recommended rate (Osweiler 1983). Triclopyr residue data from this study and large herbivore toxicological data from other studies indicate that poisoning from the proper use of triclopyr is unlikely.

Table 2. Results of regression analyses of triclopyr residues in foliage following application of 2.3 kg triclopyr ha^{-1} near Bovill, Idaho.

Species	Regression equations[1]	r^2
Shinyleaf ceanothus	$Y = 609\ X^{-0.626}$	0.83
Douglas fir	$Y = 217\ X^{-0.812}$	0.97
Mountain lover	$Y = 222\ X^{-0.655}$	0.95
Grasses	$Y = 257\ X^{-1.034}$	0.93
All foliage	$Y = 242\ X^{-0.696}$	0.69

[1]Equations are of the form $\underline{Y} = b\underline{X}^{\underline{a}}$, where $\underline{Y}$ is the triclopyr concentration in µg g^{-1}, $\underline{b}$ is a constant, $\underline{X}$ is the no. d after application and $\underline{a}$ is the exponent.

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