SOIL RESIDUES OF PICLORAM AND TRICLOPYR AFTER SELECTIVE FOLIAR APPLICATION ON UTILITY RIGHTS-OF-WAY

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Knowledge about soil residues in forests has been derived from aerial or simulated aerial applications. Soil residues after selective foliar application (SFA) have not been studied previously.

In aerial application the amount of herbicide used per unit area is known, and the larger the number of soil samples taken, the more reliable the information. In SFA the exact amounts of herbicide applied per unit area are not known because the chemicals are applied to individual trees in an area, the number of which is not constant. Furthermore, chemicals are applied through a hand-held nozzle; metering is not mechanically controlled and amounts of dispensed spray solutions fluctuate.

Areas large enough for comparable replicate plots with similar tree density were not available. Therefore, herbicides were applied to non-target vegetation (equivalent to understory) to simulate runoff from targets. The amounts of chemicals used were based on 2 gal/A Garlon 3A or Tordon 101, the largest possible amount used in field operations as estimated by utility companies.

This approach proved to be useful and it could be shown that soil residues broke down before significant leaching took place. Even under the extreme conditions of this study, the possibility for contamination of groundwater was remote.

Materials and Methods

It was the objective of this study to determine soil residues of triclopyr and picloram after selective foliar application of Garlon 3A and Tordon 101, and their potential to contaminate groundwater.

Soil residues were determined in field experiments after application of the herbicides to non-target vegetation, primarily black huckleberry (*Gaylussacia baccata*) and little bluestem (*Andropogon scoparius*), simulating 10% and 100% runoff during application. The location was chosen because the soil was very porous and the terrain moderately level (about 9% slope). One pair of plots, each plot 0.01 A in size, was used for each herbicide. Slopes and rock formations did not allow for comparable replicates which added to the design problems. To compensate for this, at least 15 soil cores were taken for one composite sample. Soil samples were taken from the top 20 in. layer with a 1 in. soil borer prior to, and 1 hour after the application, then weekly during the first month, and monthly for 3-4 months. The cores were divided into 5 in. sections for analysis. Soil samples from under trees treated with Tordon 101 in a regular field operation were taken similarly. The area under each target was too small (9 sq. ft.) for the taking of more than 5 cores for one composite sample, and at least six composite samples per target were needed to study persistence and movement.

Sampling below 0-5 in. posed contamination problems due to layer mixing when rocks were present. However, no other sampling method was applicable.

Soil from the area of the field experiments was used for leaching tests using 40×600 mm chromatographic columns. The herbicides were applied in aqueous solutions equivalent to 10% runoff. A simulated rainfall equivalent to 1 in. in 1 hour was applied 1 hour after application of the chemical, and two columns were prepared for analysis one hour after the simulated rainfall. Each column was divided into the top 4 in. layer, and three 5 in. subsoil layers. Every week the remaining columns received 1 in. of simulated precipitation, and two columns were prepared for analysis. After 4 weeks the last pair of columns had received 5 in. of simulated precipitation. Details about the preparation of the soil samples for the leaching tests are reported elsewhere (Deubert, 1985).

In the field experiments triclopyr and picloram

were applied as Garlon 3A and Tordon 101 with a portable sprayer at rates of 0.6 and 6.0 lb/A, and 0.1 and 1.0 lb/A ae, respectively, on October 5, 1982, and July 28, 1983. These quantities were considered the highest possible amounts used per acre in field operations. The field operation took place in southern New Hampshire. A 1% dilution of Tordon 101 was applied using a hydraulic spray truck.

Soil samples were analyzed for triclopyr and picloram using methods of McKellar (1977) and Bjerke (1973), respectively. Recovery of triclopyr from fortified soil samples was 89.2% (SD 5.3, n=6) at 0.5 ppm, and 64.8% (SD 9.6, n=8) at 0.05 ppm. Sensitivity limit was 0.01 ppm. Recovery of picloram was 105.0% (SD 0.4, n=4) at 0.1 ppm, and 92.2% (SD 12.1, n=4) at 0.01 ppm. The sensitivity limit was 0.01 ppm.

Results and Discussion

Interception by vegetation determines the initial amounts of soil residues. Rates of interception varied considerably (Table 2). Interception was highest in the 100% runoff plots where vegetation consisted primarily of grass. There was more brush than grass in the 10% runoff plots. Based on findings reviewed by Norris (1981) it was assumed that grass intercepted more spray solution than the brush because of its larger total leaf surface.

Sirons et al. (1977) found greater than 50% interception by grass along a freeway in Canada, and Merkle et al. (1966) determined 80-90% interception by a dense cover of live oak. Considering these data it is safe to assume that the average interception on utility rights-of-way is 50%.

Small initial soil residues are associated with high initial rates of degradation and the more interception, the smaller the chance of leaching to greater depths.

Persistence in soil was determined using data of the leaching experiments since neither compound leached in measurable quantities in these tests. Residue levels of triclopyr (Table 3) suggest a half-life of about 10 days which is slightly less than 14-16 days found by McKellar et al. (1982) in the field.

The half-life of picloram (Table 3) was about 8-10 days which does not agree with available information. However, Grover (1967) and Hamaker et al. (1968) reported lag periods in picloram degradation which depended on initial quantities. At 0.4 ppm, significant decomposition started within a week. These authors calculated half-lives from 0.5 to 5.4 months depending on soil pH and initial concentration. The initial amount used in this study was 0.12 ppm. If sampling had started one or several months after application, calculated half-lives would have been considerably longer.

The apparent half-life of picloram in the field was longer than in the leaching test due to replenishment from vegetation washoff (Table 5). The data of 9-29-83 in Table 5 should be looked at critically because of the sampling problems described above.

Movement of both chemicals in the field and in their leaching experiments was restricted by soil organic matter since the clay content of these plots was less than 0.5%.

Most triclopyr residues were found in the 0-10 in. layer, with small amounts in the 10-20 in. layer (Table 4). This observation was verified by the results of the leaching tests (Table 3). Norris et al. (1976) detected 0.11 ppm triclopyr once in the 6-12 in. layer of a pasture six months after the application of 3 lb/A ae. These authors found 90+% of the total residues in the upper 2 in. layer.

Highest picloram residues were found in the 0-10 in. layer of both the 10% and the 100% runoff plot (Table 5) as well as in the field operation (Table 6). Samples taken two months after application may not be representative due to contamination during sampling. In the first set of columns of the picloram leaching test the top 4 in. layer was divided into two 2-in. layers for separate

Table 1. Soil characteristics. Column A: Field experiments. Column B: Field operation. Except for pH, data are in percent.

	0-5 in.		*5-10 in.*		*10-15 in.*	
Soil	*A*	*B*	*A*	*B*	*A*	*B*
Coarse sand	53.8	46.3	52.4	43.6	54.2	35.6
Fine sand	39.5	37.8	42.9	38.7	41.3	44.0
Silt and clay	6.7	15.9	4.7	17.8	4.5	20.8
Organic matter	2.5	3.2	<0.4	2.2	<0.4	1.3
pH	5.0	5.2	5.2	5.4	5.4	5.3

analysis, and 79% of the initial amount was detected in the top 2-in. layer.

Baur et al. (1972) found less than 0.019 ppm picloram at 6-12 in. 30 days after application of 1 lb/A picloram to a fine sandy loam, and 0.007 ppm at 43-49 in. 6 months after application and after 15 in. cumulative rainfall. Norris (1971, 1972) reported that 6 months after the application of 1 lb/A picloram on a utility right-of-way in Oregon most of the herbicide remained in the top 6 in.

Table 2. Field experiment. Predicted and actual soil residues 1 h after application, and calculated interception by non-target vegetation. Data based on top 5 in. soil layer. Rates of application: Triclopyr 0.6 and 6.0 lb/A, picloram 0.1 and 1.0 lb/A.

	10% Estimated runoff			*100% Estimated runoff*		
Herbicide	*Predicted ppm*	*Found ppm*	*Retained %*	*Predicted ppm*	*Found ppm*	*Retained %*
Triclopyr	0.39	0.19	51.3	3.89	0.52	86.6
Picloram	0.07	0.05	28.6	0.70	0.05	92.9

Table 3. Leaching experiments. Initial amounts: 0.6 lb/A triclopyr and 0.1 lb/A picloram equivalent to 10% assumed runoff. Results in ppm, means of two replicates.

Layer	*Weeks*				
in.	*0*	*1*	*2*	*3*	*4*
			Triclopyr		
00-04	0.42[1]	0.27	0.07	0.04	0.03
04-09	N.D.	N.D.	N.D.	N.D.	N.D.
09-14	N.D.	N.D.	N.D.	N.D.	N.D.
14-19	N.D.	N.D.	N.D.	N.D.	N.D.
			Picloram		
00-04	0.12[2]	0.07	0.02	0.02	0.02
04-09	N.D.	N.D.	0.02	N.D.	N.D.
09-14	N.D.	N.D.	N.D.	N.D.	N.D.
14-19	N.D.	N.D.	N.D.	N.D.	N.D.

[1]Predicted 0.49 ppm.
[2]Predicted 0.08 ppm. Actual picloram residues: 0.19 ppm in the 0-2 in. layer, 0.05 ppm in the 2-4 in. layer.

Table 4. Field experiment. Soil residues after the application of 0.6 and 6.0 lb/A triclopyr to non-target vegetation equivalent to 10% and 100% assumed runoff from target vegetation. Data in ppm are the means of two layers. Each composite sample consisted of at least 15 soil cores representing a 0.01 A area.

Layer in.	*10-5-82*	*10-12-82*	*10-19-82*	*10-27-82*	*11-2-82*	*11-30-82*	*12-28-82*
				10% Assumed runoff			
00-10	0.08	0.04	N.D.	<0.01	N.D.	*	N.D.
10-20		N.D.	N.D.	N.D.	N.D.	*	N.D.
				100% Assumed runoff			
00-10	0.23	Lost	0.27	0.31	0.45	0.04	0.03
10-20		Lost	<0.01	N.D.	N.D.	N.D.	N.D.

*Not analyzed because of the previous results.

Table 5. Field experiment. Soil residues after the application of 0.1 and 1.0 lb/A picloram as Tordon 101 to non-target vegetation equivalent to 10% and 100% assumed runoff from target vegetation. Data in ppm are the means of two layers. Each composite sample consisted of at least 15 cores representing a 0.01 A area.

Layer in.	*7-28-83*	*8-5-83*	*8-11-83*	*8-19-83*	*8-26-83*	*9-30-83*	*10-26-83*	*12-16-83*
				10% Assumed runoff				
00-10	0.03	0.06	N.D.	0.03	0.03	N.D.	0.18	0.01
10-20		0.01	N.D.	N.D.	0.04	N.D.	N.D.	N.D.
				100% Assumed runoff				
00-10	0.03	0.26	0.11	0.07	0.07	0.03	0.08	N.D.
10-20		0.03	N.D.	0.02	0.02	N.D.	0.01	N.D.

Table 6. Field operation. Soil residues of picloram after application of 1% Tordon 101 with a hydraulic spray truck. Data in ppm are the means of two layers. Each composite sample consisted of 5 cores representing an area of 9 sq. ft. Targets A and B were 20 feet apart.

Layer in.	*7/26/83*		*8/2/83*		*8/10/83*		*8/17/83*		*8/24/83*		*9/29/83*	
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*
00-10	0.04	0.04	0.11	0.15	0.11	0.13	0.03	0.09	0.03	0.16	0.08	0.08
10-20					N.D.	N.D.	0.02	N.D.	0.01	0.01	0.03	0.05
20-30											0.01	0.05

layer of the soil. Rainfall was 25 in.

Sirons et al. (1977) reported highest picloram residues (0.1-1.4 ppb) at 12-18 in. 2.1 and 11.6 months after spraying of 0.3 lb/A picloram as Tordon 101 along a freeway in Canada. Norris (1981) noted that in the forest environment picloram was substantially less mobile than in the agricultural environment. On several utility rights-of-way in Oregon and Washington, residues of picloram showed rapid decline, and no leaching to depths below 12 in. was detected at sites ranging from low to high temperature and rainfall (Norris et al., 1976).

Conclusion

For quantities of material applied in selective foliar application on utility rights-of-way, initial soil residues are small due to 30-90% interception (average about 50%) by non-target vegetation. Soil residues increase during the first 1-4 weeks after application due to washoff from vegetation. However, the rate of breakdown is faster than the rate of accumulation and soil residues of both chemicals decrease after 2-4 weeks. Leaching of picloram, the more mobile of the two chemicals studied, below 20-30 in. is improbable. However, the use of larger amounts of picloram (e.g., 3 lb/A ae, equivalent to 6 gal/Tordon 101) may lead to leaching below 20-30 in.

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