

Effects of Fall Burning of Chaparral Woodland on Soil Residues of Picloram¹

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Abstract. Residue of picloram (4-amino-3,5,6-trichloropicolinic acid) aerially sprayed onto a central Arizona chaparral stand was markedly reduced in the surface 7.6 cm of soil from a fall burn conducted 5 weeks later. Brush control was also reduced.

Additional index words. Shrub live oak, *Quercus turbinella*, fire effects, canopy interception, soil chemistry.

INTRODUCTION

Picloram is an effective brush control agent. One reason for its effectiveness is its persistence in the soil, which helps to kill dormant buds that begin to grow after a shrub's top growth has been damaged or killed. Fire is often used with herbicides to control the mixture of brush species found in chaparral woodlands. Planned burning during periods of low fire hazard helps to alter stand density and composition, reduce potential soil loss and wildfire hazards (10, 11). Such burning is usually done after herbicides are applied to prepare the site by killing green leaves and some of the woody growth (8). However, information is needed on the effects of using fire to remove dead brush after application of effective brush-control herbicides such as picloram.

The fate of picloram under such conditions is unknown. This is a report of the effects of a fall fire, 5 weeks after treatment with picloram on the picloram residues in soils under a central Arizona chaparral stand.

MATERIALS AND METHODS

A mixture of picloram and 2,4-D [(2,4-dichlorophenoxy)

acetic acid] as triisopropanolamine salts was applied aerially onto a 4-ha mixed species chaparral stand at Metate, Arizona, in late August. An average of 2.2 kg acid equivalent (ae) of picloram and 4.4 kg ae of 2,4-D in 38 L of water hectare was applied. Small amounts of diesel oil were added as needed to the spray mixture to control foaming. Five weeks later half of the area was burned as part of a prescribed fall burning project. Responses of vegetation in both halves of the area were recorded for 3 yr. Shrub live oak (*Quercus turbinella* Greene) was the only shrub found throughout the area.

The soils were not identified but are slightly acid, coarse textured, gravelly loam sands derived from granitic parent material. Just before and after burning, soil samples for herbicide assay were collected at depths of 0 to 2.5, 2.6 to 7.5, and 7.6 to 15.2 cm from the sides of shallow pits dug underneath and between shrub live oaks. Three randomly selected locations on the burned and unburned halves of the area were used. One kilogram of soil was collected into double-walled plastic bags from each depth at each location. All tools and the pit sides were cleaned after collection at each depth to avoid contamination of one layer of soil by another. Gravimetric soil moisture was determined on an oven-dry-weight basis in triplicate samples taken at the same time the herbicide assay samples were taken.

The soils were air-dried and stored in an unheated warehouse at Flagstaff, Arizona and assayed for herbicidal activity within 2 months after collection. Preliminary tests with safflower (*Carthamus tinctorius* L.) seedlings grown 72 h on soil in petri dishes were used to identify soils needing dilution for further assays. Soil dilutions were made as needed by adding washed fine quartz sand to treated soils. Picloram activity was determined with soybeans [*Glycine max* (L.) Merr.] grown 2 weeks in Styrofoam cups containing 100 g of treated soils.

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Their growth was then compared with that of soybeans grown in similar but untreated soils to which known concentrations of picloram had been added. The results of earlier trials indicated that the presence of 2,4-D would not interfere with picloram determinations when the herbicide mixture was diluted to a picloram concentration of 1 to 16 ppbw in soils from the study area. Assays for 2,4-D were not done. There were three replications within a randomized block experimental design; the assays were done twice. Data were subjected to an analysis of variance and, where applicable, to Duncan's multiple range test.

RESULTS AND DISCUSSION

Fire reduced the amount of picloram in soil between bushes from 2.4 kg/ha to 0.15 kg/ha (Table 1). Most of this reduction took place in the upper 7.5 cm of soil. Almost all of the herbicide was found at this depth because about 2.79 cm of rain fell during the five weeks between application and burning that would readily leach the water soluble picloram. When the herbicide was being applied, the surface 2.5 cm of soil was dry, with only 2 to 6%; however, soils below 2.5 cm were moist, with 11 to 16% moisture. At the time of burning the surface 15 cm of soil contained only 2 to 6% moisture. Variations of the picloram content of soil taken before the fire and from the unburned area were not significant and are likely due to variation in application and sampling.

Little picloram was detected in soils under shrub live oak canopies (Table 2). The average concentration of picloram found under the canopy before the fire was very low, ranging from 3 to 33% of that found in soils from adjacent bare areas. The low concentration of picloram detected may in part be due to its interception by the shrub canopy and duff, to adsorption of the herbicide onto soil organic matter, or a combination of these mechanisms. It is believed that most of the picloram was intercepted by the shrub canopy. Any herbicide on the foliage or the litter under the plants would be lost when fire consumed them. Picloram deposited on the foliage would also be subject to loss from photodecomposition.

Table 1. Average amounts of picloram in different layers of soil between bushes in an Arizona chaparral stand just before and after a fall fire^a.

Soil layer (cm)	Picloram content of soil ^b			
	Unburned		Burned	
	Before	After	Before	After
0 to 2.5	1.12a	0.75a	0.96a	0.06b
2.6 to 7.5	0.88a	1.12a	1.41a	0.08b
7.6 to 15.2	0.03b	0.03b	0.03b	0.01b
Total	2.03	1.90	2.40	0.15

^aPicloram was applied at the rate of 2.2 kg/ha 5 months before the fire.

^bMeans followed by the same letter do not differ significantly at the 5% level, according to Duncan's multiple range test.

Table 2. Average amounts of picloram in different layers of soils under and between shrub live oak canopies in both burned and unburned areas before burning^a.

Soil layer (cm)	Picloram content of soil ^b	
	Under canopy	Between canopies
0 to 2.5	0.15b	1.04a
2.6 to 7.5	0.03c	1.14a
7.6 to 15.2	0.01c	0.03c
Total	0.19	2.21

^aPicloram was applied at the rate of 2.2 kg/ha 5 weeks before the fire.

^bMeans followed by the same letter do not differ significantly at the 5% level according to Duncan's multiple range test.

Soybeans grown on soils sampled from under burned bushes did not show toxic effects of the herbicide even after picloram at 25 to 50 ppbw was added to these soils. This concentration of picloram is equivalent to about 0.11 to 0.22 kg of picloram per hectare diluted throughout 30 cm of soil, which is more than the lower concentrations detected on other soils in this study. It is assumed that the charcoal and ash from the burned shrubs absorbed the herbicide.

The fire was typical of chaparral burned in the fall. It was spotty; denser portions of the stand burned well, but where clumps were scattered, the fire often had to be spread manually from clump to clump. Except for the larger stems, most of the shrubs and underlying litter were consumed. Soil surface temperatures under intense fires, such as those consuming large brush clumps, may exceed 700 C (4). Such temperatures are high enough to decompose picloram, the acid of which decomposes without melting at 215 C (12). Temperatures below the soil surface during a fire depend mainly on the intensity and duration of the fire, and the amount of water in the soil (4). The more water in soil, the slower the heat transfer, since soil temperatures will not much exceed 100 C until the water is gone. Downward heat transfer is more rapid in dry soils. If the soils had contained more water or the picloram had been leached further, less picloram might have been lost. However, the conditions encountered were normal for the location. Therefore, marked losses of picloram from near the soil surface would be expected under bushes burned in Arizona chaparral.

It is doubtful that subsurface temperatures in soil between burning shrubs exceeded 200 C, yet the loss of picloram from these soils was marked (Table 1). This loss could be due to picloram decomposition by heat, absorption by charcoal, dissipation by volatilization, or a combination of these mechanisms.

Nonbiological degradation of picloram occurred in soil incubated at 95 C, and degradation was fast enough to suggest this as a possible pathway for picloram loss (7). However, it is unlikely that soil temperatures between burning shrubs were at elevated temperatures for more than a few minutes.

Thus, only a small amount of picloram might be degraded in this manner.

Picloram is readily absorbed by activated charcoal (2, 6). However, sensitive plants were unable to grow on an area treated with picloram at 0.56 kg/ha even after as much activated charcoal as 672 kg/ha had been added to the soil (2). Nonetheless, fresh charcoal from burned shrubs might also readily absorb picloram. This absorption might be important underneath burned plants but not in soil between plants; little charcoal was evident on or in the soil between burned shrubs in this study.

Plants have been damaged by picloram vapors in closed-system laboratory trials (5); vapor losses are low at normal air and soil temperatures (13) but should accelerate at higher temperatures (3). Picloram dissipates more rapidly from soil at 38 C than lower temperatures (9). Almost half of the exposed isooctyl ester of picloram dissipated in a week at 60 C, but very little of the potassium salt was lost (1). Vapor dissipation of the amine salts may be an important cause of their loss from heated soils between burning bushes. Vapors of picloram might escape in smoke and dust particles, be consumed by flames, or be decomposed by exposure to ultraviolet radiation in sunlight.

Fire reduced the effectiveness of picloram in controlling shrubs. Before the fire, herbicide damage was just becoming evident on the shrubs with foliage damage ranging from 50 to 100%. The following spring, 96% of the burned shrub live oak clumps had robust basal sprouts 0.1 to 0.3 m tall with very little herbicide effect. Manzanita (*Arctostaphylos* spp.) seedlings were common and grass seedlings were numerous. On the unburned area, herbicide damage to the top growth on the shrubs ranged from 70 to 100%; the few oak sprouts present had cupped leaves and shortened stem internodes, which are characteristic responses to picloram. There were no manzanita seedlings on the unburned area, although grass seedlings were also common. After three years only 2% of the shrub live oak were dead on the burned area, while 21% were dead on the unburned area.

Application of picloram sprays earlier in August might improve the postfire responses of the shrubs to the herbicide. More of the herbicide might be within the roots and stems,

and, during a normally wet August, more of the herbicide would be moved deeper into the soil, where fire might not affect it.

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