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Several Factors Affecting the Response of Pricklypear to 2,4,5-T[1]

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Abstract. A laboratory assay method was developed for studying pricklypear (*Opuntia* sp.) responses to herbicides. Herbicidal translocation from one pad to another and lateral translocation across a pad appeared to be very slight. Pads were killed when a butoxy ethanol ester, a propylene glycol butyl ether ester, or a 2-ethylhexyl ester formulation of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) was applied to only one side. Increasing temperatures from 21 to 43 C increased the rate of killing pads. Concentrations of 2,4,5-T at 8 lb aehg of solution usually killed the pad at temperatures above 21 C. Concentrations of 2,4,5-T at 4 lb aehg or less had little effect on the pads. Relative humidity level had little effect on 2,4,5-T activity, but the activity of a propylene glycol butyl ether ester of 2,4-dichlorophenoxyacetic acid (2,4-D) was more effective at the 90 to 95% level than at levels ranging from 30 to 75%. Water, diesel oil, and three diesel oil:water mixtures had little effect on 2,4,5-T toxicity. More toxic effects were shown by 2,4,5-T than 2,4-D. The propylene glycol butyl ether ester, the butoxy ether ester, and the 2-ethylhexyl ester of 2,4,5-T were equally effective on pricklypear at the same concentrations.

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Introduction

Pricklypear (*Opuntia* sp.), a serious invader, infests rangeland of the Southwest. In Texas alone, over 35 million acres are infested with cactus species, most of which is pricklypear (6).

Pricklypear generally is controlled most economically on large acreages by mechanical methods. On rough terrain the plants usually are grubbed, piled, and burned. On level areas, railing, i.e. dragging a series of steel rails across the area during a dry season, has given good control, especially when followed by grazing. Chemical control of individual plants, which may be too expensive on dense stands, is used primarily on sparse stands. In Texas, the recommended herbicidal treatment consists of 8 lb aehg of a low volatile ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) in diesel oil applied as a wetting spray when the plants are growing vigorously during warm weather (3, 5, 7). Esters of 2-(2,4,5-trichlorophenoxy)propionic acid (silvex) also have been effective for controlling pricklypear[3]. Recently, 4-amino-3,5,6-trichloropicolinic acid (picloram) was shown to be effective for control of pricklypear (4).

This study was initiated to evaluate some of the factors affecting control of pricklypear by herbicides. The factors included coverage, temperature, humidity, and chemical formulations.

Materials and Methods

A simple assay method was devised to evaluate the treatments in the laboratory. Pricklypear stems collected near Wellborn and Caldwell, Texas, were cut into one and two-pad sections. Two-pad sections were used only to demonstrate translocation characteristics. The pads were laid in 8-in aluminum foil pans. Herbicidal solutions were brushed on the top surface of the pad with a small brush at the rate of 1 ml of herbicide solution per 400 sq cm upper pad surface area. The propylene glycol butyl ester (PGBE) ester of 2,4,5-T was used in all experiments except where otherwise stated. The treated pads were held at 32 C and 50 to 75% relative humidity except where otherwise stated. Controlled environment chambers described by Behrens and Morton (1) were used for all experiments, except where 2,4,5-T esters were compared on pads stored at room temperature (18 to 35 C). Visual injury ratings were made on each pad. Ratings were assigned from 0 as no injury to 100 when the entire pad was decomposed. All results are expressed as percent injury.

In the translocation experiment, 10 stem sections with two pads each were used. The terminal pads on five and the second pads on the other five stem sections were treated with an 8 lb aehg solution of the PGBE ester of 2,4,5-T in diesel oil. Injury was evaluated 18 days after treatment.

In the first temperature experiment, pads were treated with water, diesel oil, an 8 lb aehg solution of the PGBE ester of 2,4,5-T in diesel oil, and the undiluted 400 lb aehg PGBE ester of 2,4,5-T and placed in controlled environment chambers set at 21, 30, and 38 C at 30 to 35% relative humidity. Six pads were used in each treatment. Injury was evaluated 18 days after treatment. In the second temperature experiment, pads were treated with the PGBE ester of 2,4,5-T at 8 lb aehg. Nine treated pads were held at each of 32, 38, and 43 C for 17 days. Water and diesel oil controls were held at 32 C.

In the experiment with a relative humidity variable, eight pads were used for each treatment of an 8 lb aehg solution of PGBE esters of 2,4,5-T and 2,4-dichlorophenoxyacetic acid (2,4-D) in diesel oil. The environment chambers were set at 30 to 35, 40 to 45, 70 to 75, and 90 to 95% relative humidity at 32 C. Percent pad injury was recorded 24 days after treatment.

Two formulation experiments were conducted. In the first, the butoxy ethanol ester of 2,4,5-T was applied in water, diesel oil, and 3:1, 1:1, and 1:3 (v/v) combinations of diesel and water at concentrations of 0, 1.6, and 8 lb aehg in each carrier. A 1% (v/v) quantity of a nonionic surfactant (nonyl phenyl polyethylene glycol ether) was added to all treatments. Nine pads were treated in each treatment. In this experiment, only a 60 by 68-mm rectangle was marked off on the upper surface of each pad with a wax pencil. A 0.1-ml aliquot of chemical solution was brushed uniformly on the marked area. The pads were rated for injury after being in the controlled environment chambers for 22 days. In the second formulation experiment, nine pads were treated each with 0.4, 0.8, 4, and 8 lb aehg of the butoxy ethanol, the propylene glycol butyl ether, or the 2-ethylhexyl ester of 2,4,5-T. The pads were maintained in the controlled environment chamber for 30 days.

[3]Alley, H. 1962. Cactus control (*Opuntia* spp.) Dec. Issue, Crop Care. University of Wyoming. Laramie, Wyoming.

Results and Discussion

Translocation. Apparently very little translocation of the toxic agent occurred because only the treated pads were killed regardless of whether the upper or lower one was treated (Table 1). The surface of the pad treated with 2,4,5-T first blistered. Later, the tissue turned brown, necrotic, and finally dried. The slight amount of injury to the untreated pad was due to surface movement of the herbicidal solution after application. This result agrees with observations in the field in which complete coverage of the plant has been requisite for control. Frequently, only part of the pad is killed, and the remaining live tissue is capable of regenerating a new plant. Aerial spraying generally has been unsuccessful in killing pricklypear, probably because of the inability to obtain complete coverage of the upright randomly oriented pads. Chow (2) also found silvex translocated very slowly in pricklypear plants.

Table 1. Percent injury caused by 2,4,5-T applied to one of two-pad pricklypear sections.

Treatment	Terminal pad	Lower pad
Terminal pad treated	97	8
Second pad treated	1	88

Temperature. In Texas, the highest percentage of successful treatments have occurred when the spraying is done during July and August. Winter treatments have been less effective. In the first experiment, injury to pads treated with the 8 lb aehg concentration of 2,4,5-T increased as the temperature increased (Table 2). These results corroborate observations in the field that phenoxy herbicides are most effective at high temperatures. The undiluted formulation killed the pads at all temperatures. The water controls were not injured at any temperature level.

Table 2. Percent injury of pricklypear pads treated with 2,4,5-T and held at three temperatures for 18 days after treatment.

Treatment	Temperature (C)[a] 21	30	38	Mean
Water	0c	0c	0c	0x
Diesel oil	0c	0c	10cd	3x
8 lb aehg 2,4,5-T in diesel oil	15d	56e	86f	32y
Undiluted 400 lb aehg 2,4,5-T formulation	100f	100f	100f	100z

[a]Numbers followed by the same letter do not differ significantly at the 5% confidence level.

Increasing temperatures increased the rapidity for killing the pads (Table 3). The 8 lb aehg 2,4,5-T emulsions killed most of the pads over a period of time, but the rate, at least in the growth chambers, was dependent on temperature.

Table 3. Percent injury to pricklypear pads treated with 2,4,5-T and held at three temperatures after treatment.

Treatment[a]	Temp C	Days after treatment[b] 7	17
Water control	32	0d	0x
Diesel oil control	32	7d	48y
2,4,5-T in diesel oil	32	44e	98z
2,4,5-T in diesel oil	38	58f	97z
2,4,5-T in diesel oil	43	90g	100z

[a]2,4,5-T was applied at 8 lb aehg.
[b]Numbers followed by the same letter do not differ significantly at the 5% confidence level.

Humidity and chemicals. Pad injury was slightly higher at 90 to 95% relative humidity than at the three lower levels (Table 4). At the end of 24 days in the 90 to 95% relative humidity level, all pads treated with 2,4,5-T and 95% of the pads treated with 2,4-D were dead. The 2,4-D was less effective than 2,4,5-T at all humidity levels. Observations in the field indicate that 2,4,5-T and silvex are the most effective chemicals on pricklypear while 2,4-D is less effective.

Table 4. Percent injury to pricklypear pads maintained at four humidity levels for 24 days after treatment with 2,4,5-T or 2,4-D.

Treatment[a]	Percent relative humidity 30 to 35	40 to 45	70 to 75	90 to 95	Mean[b]
Untreated	2	4	0	2	2x
2,4,5-T in diesel oil	97	99	94	100	95z
2,4-D in diesel oil	84	75	72	95	82y

[a]The herbicides were applied at 8 lb aehg.
[b]Numbers followed by the same letter do not differ significantly at the 5% confidence level.

Increasing 2,4,5-T concentration increased injury to the pads (Table 5). Diesel oil without 2,4,5-T also caused some injury. In general, the ratio of oil and water seemed to have little influence on 2,4,5-T activity.

Table 5. Percent injury of pricklypear 22 days after treatment with water, diesel oil, and diesel oil-water emulsions containing three concentrations of the butoxy ethanol ester of 2,4,5-T.

Carrier[a]	Lb aehg 2,4,5-T 0	1.6	8.0	Mean
Water	0	62	78	47
1:3 oil/water	7	75	88	57
1:1 oil/water	19	48	89	52
3:1 oil/water	32	44	69	48
Oil	22	49	94	55
Mean[b]	16x	56y	83z	

[a]A 1% (v/v) concentration of surfactant was added to each treatment.
[b]Numbers followed by the same letter do not differ significantly at the 5% confidence level.

The three esters of 2,4,5-T were about equally effective at the same rates (Table 6). The 8 lb aehg emulsions did not kill the pads entirely because only part of the pad was treated, and possibly because the temperature was not consistently high enough. The two lowest rates were essentially ineffective.

Table 6. Percent injury of pricklypear pads 30 days after treatment with four rates of three esters of 2,4,5-T.

Ester	Lb aehg herbicide concentration[a] 0.4	0.8	4	8
Butoxy ethanol	6	6	68	76
Propylene glycol butyl ether	4	7	60	77
2-ethylhexyl	4	7	60	74

[a]No injury occurred in the water and diesel oil controls.

Diesel oil alone caused injury in some experiments (Tables 2, 3, and 5) but not in the last one (Table 6). The diesel oil probably increased cell permeability as proposed by van Overbeek and Blondeau (8). The higher light intensity and mean temperatures in the growth chambers compared to the room conditions may have caused partial oxidation of the oil, making it more phytotoxic.

The assay method is a useful tool for studying factors which affect herbicidal activity on pricklypear. The pads are easily prepared for study, since they can be collected and used without rooting in soil or given other preparative treatment. It is doubtful if chemical translocation patterns in one or two-pad sections separated from the plant are the same as those in pads attached to intact plants. However, one and two-pad sections frequently are found in the field after mechanical or chemical treatments on pricklypear, and methods for the control of short stem sections are needed to prevent reinfestation of rangelands. The agreement of results from these experiments with those from field experiments indicates that the method has potential value for rapid evaluation of chemicals for pricklypear control.

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