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Journal
Proceedings of the Vertebrate Pest Conference, 15(15)

ISSN
0507-6773

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Publication Date
1992

A STUDY OF ACROLEIN AS AN EXPERIMENTAL GROUND SQUIRREL BURROW FUMIGANT

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ABSTRACT: Acrolein (Magnacide® H) is currently registered in California as an aquatic herbicide. Field tests were conducted to evaluate its efficacy as a ground squirrel burrow fumigant. Treatments consisted of applying either 20 cc or 40 cc of acrolein (92%) per burrow opening with a specially constructed probe connected to a hose which ran to a cylinder mounted on a pickup truck. The burrow opening was plugged at the time of the application. Burrows in the control plot were plugged in the same manner. Dig-outs and open burrows overlooked during the initial application were re-treated the following day. Both rates of acrolein showed a substantial reduction in the ground squirrel population, in excess of 90%, when adjusted for changes in the population in the control plot. The results appear very encouraging with further field testing warranted.

Proc. 15th Vertebrate Pest Conf. (J. E. Borrecco & R. E. Marsh, Editors) Published at University of Calif., Davis. 1992

INTRODUCTION

The California ground squirrel (*Spermophilus beecheyi*) causes serious economic damage to rangeland, agricultural crops and ditch banks in California. Burrow fumigants are often used to control populations from late winter, following the emergence of the squirrels from hibernation, into early summer, when the ground becomes too dry and gases leak out of the burrow systems due to surface cracks.

Some burrow fumigants that were used in the past for squirrels are no longer registered. Carbon bisulfide was banned many years ago as a burrow fumigant, and methyl bromide is currently being phased out.

Few new toxicants or fumigants are being developed and registered for field use to control pest rodent species. Costs of registration can be prohibitive because of the very limited potential market especially since toxicants are usually formulated at very low concentrations on grain baits. If materials such as acrolein that have already been registered for other uses can be adapted for field use to control rodents, costs can be kept minimal, because much of the data required will already have been generated.

Acrolein has been used as a herbicide for many years, hence there exists substantial data on the material. It is very toxic to mammals when inhaled but it has a short life in the environment, when applied as a herbicide, and presumably so as a rodent burrow fumigant. Acrolein at low doses is irritating to the throat and eyes so it serves as its own warning agent (Baker Performance Chemicals Inc. 1989). Acrolein has a number of characteristics which favor its potential use as a rodent burrow fumigant. This, coupled with a keen interest of the marketing company in pursuing registration plus a critical need for new materials for ground squirrel control, prompted these studies.

STUDY AREA

The study area was located in Alameda County, California, approximately five miles southwest of Livermore. The study area was on rangeland on a 3,000 acre ranch off of Highway 84. The two treatment plots were on relatively flat ground to allow a vehicle access to transport the canisters of Magnacide® H and nitrogen. The control plot was located on slightly steeper terrain, as vehicle access was not necessary. All plots were predominately annual grasses with some broadleaves present, such as redstem filaree (*Erodium cicutarium*). The sizes of the plots varied somewhat with Plot 1 = 2.3 acres, Plot 2 = 3.3 acres and Plot 3 = 2.0 acres. The plots were rectangular in shape and the boundaries were well marked. Plots 1 and 2 were approximately 300 ft. apart and the control plot (Plot 3) was approximately 1,500 ft. from Plot 2 which was the nearest to the control. All burrow openings were flagged when the plots were set up. No squirrel control had been conducted on this ranch in the study location for at least two years prior to this study and hence the squirrel population was considered moderate to high.

METHODS AND MATERIALS

Each treatment plot was chosen to encompass a total of approximately 700 burrow openings which included both active and inactive openings. The control plot had 370 burrow openings. Two hundred foot buffer zones surrounding the perimeters of the control and two test plots were either treated with methyl bromide or aluminum phosphide.

Twelve days prior to the acrolein fumigant treatment all burrow openings in the control and treatment plots were covered with soil, so that at treatment time only active burrows (i.e. those that had been reopened) would be treated. Plot 1 (the designated 20 cc treatment plot) had 711 burrows covered with soil, Plot 2 (the designated 40 cc treatment plot) had 689 burrows covered with soil, and Plot 3 (the designated control plot) had 370 burrows covered with soil during the pre-treatment burrow closures.

Of the original 711 burrow openings closed 12 days pretreatment in plot 1 only 268 (38%) were reopened and considered active at treatment time. In plot 2, of the original 689 burrow openings closed, 312 (45%) reopened and in the control plot (Plot 3) 370 were originally closed with 198 (53%) reopened at the time of treatment. Those burrow openings not reopened were considered inactive and not treated and do not enter into any of the subsequent calculations on the percentage of control.

Treatment of the 200 foot buffer zones around the plots required 7,000 aluminum phosphide tablets (at two tablets

Table 1. Results of the two treatment rates based on the visual squirrel indexes pre and post-treatment.

Plot and Treatment	Plot Size (acres)	Average No. of Squirrels Pre-Treatment	Average No. of Squirrels Post-Treatment	% Reduction Uncorrected	% Reduction Corrected[a]
1 (20 cc)	2.3	26.7	1.5	94.4	93.9
2 (40 cc)	3.3	27.6	2.3	91.7	90.9
3 (Control)	2.0	25.1	23.0	8.4	——

[a]These values have been adjusted based on the changes occurring in the control (untreated) population.

per burrow opening) and 72 (1.5 lb.) cans of methyl bromide applied at about 20 cc per opening. The total squirrel holes treated in the buffer zones were approximately 4,500.

Each plot was censused separately. Two separate population indexes (i.e. census methods) were used to measure changes in the squirrel population pre-treatment versus post-treatment. The first method consisted of visually counting ground squirrels on the plots for specified period of time for a three day period before the treatment with the post-treatment counts starting three days after treatment. Visual counts have long been used for evaluating squirrel control in California and have been shown to have good reliability (Fagerstone 1983).

Each squirrel seen during five separate scans at five minute intervals was counted. Counts were made from inside a vehicle using 7 x 50 power binoculars and were taken from the same location each time. Counts were originally planned to be taken only once per day, but it was decided to take two per day after the counts had begun because rainy weather and periodic disturbance from cattle interrupted some counts which had to be omitted.

The second census method consisted of counting the number of known active ground squirrel burrows which were closed during the treatment and then recounting those re-opened eight days after treatment. From these values the change in population activity could be calculated.

The acrolein treatments were conducted on March 23, 1992 with a follow-up treatment of missed and re-opened burrows occurring the following day. The application equipment consisted of a cylinder of 92% acrolein (Magnacide® H) which when full weighs 370 pounds and holds approximately 30 gallons (at 7.06 lbs./gallon). The Magnacide® H cylinder was connected to a cylinder of nitrogen, which is used to pressure the Magnacide® H from its container. Other equipment included a custom built Spraying Systems Meter Jet Gun with a 36 inch nozzle extension with a positive shut off. The gun could be calibrated to deliver from 1 to 16 cc of Magnacide® H. We calibrated it on location and adjusted it to deliver 10 cc so the 20 cc plot took two squirts (i.e. two trigger pulls) and the 40 cc plot took four squirts.

In addition to the gun, a 50 foot, 1/4 inch stainless steel braided teflon hose was connected with a 1/4 inch brass swivel to the gun with another swivel at the Magnacide® H container. The nitrogen tank is connected by a six foot hose to a pressure regulator connected to the Magnacide® H cylinder. The cylinder is pressurized to an operation pressure of 25 psi.

Treatments consisted of applying 20 cc to each recently opened active burrow entrance in Plot 1, or 40 cc to burrows in Plot 2. The acrolein was applied and the opening immediately sealed with soil. Burrows in the control plot were not treated, but were covered with soil in the same manner as the treatment plots. The number of treated burrows in each plot was recorded. In this experimental study the treatment of Plots 1 and 2 required approximately two hours per plot with a four person team.

Soil moisture in all plots was high due to recent rains so fumigant retention in the burrow systems should have been good.

RESULTS AND DISCUSSION

The mean pre-treatment visual counts for each plot to establish the activity index were: Plot 1 – 26.7 squirrels, Plot 2 – 27.6 squirrels and Plot 3 – 25.1 squirrels. Average post-treatment counts were: Plot 1 – 1.5, Plot 2 – 2.3 and Plot 3 – 23.0 squirrels. In the control plot, where only a sham treatment occurred (filling burrows with soil), the number of squirrels observed decreased by about 8 percent between the pre and post-treatment period. The visual count changes for the treatment plots when adjusted for changes in the control plot showed population reductions of 93.9% in Plot 1 and 90.9% in Plot 2 (Table 1). These figures were obtained by the following formulas:

Formula 1 –

$$\frac{\text{No. of squirrels pre-treatment (treated plot)}}{\text{No. of squirrels in control plot (pre-treatment)}} = \frac{\text{Expected no. of squirrels if had no treatment}}{\text{No. of squirrels in control plot (post-treatment)}}$$

Formula 2 –

$$\frac{\text{Remaining no. of squirrels}}{\text{Expected no. of squirrels}} \times 100 = \text{Adjusted \% remaining}$$

Formula 3 –

$$100 - \text{Adjusted \% remaining} = \text{\% Adjusted control}$$

The active burrow count index method showed 61% of the burrows were re-opened in the control plot eight days after they were filled with soil (120+198). For the treated plots, Plot 1 had 268 treated with 18 re-opened 8 days later (another 10 new or untreated burrows were also found), Plot 2 had 312 treated and also 18 re-opened (another 17 new or untreated burrows were found). This calculated out for re-opened treated burrows for Plot 1 and 2 to give 88.9% and 90.5% adjusted control, respectively (Table 2). If we calculate into the formula the newly dug burrow openings or those originally missed by both treatments then we come up with 86.5% and 85.6% respectively for Plots 1 and 2, when

Table 2. Results of the two treatment rates based on active holes and holes re-opened following treatment.

Plot and Treatment	Number of Burrows Treated	Number of Burrows Re-treated (1 day)	Number Re-opened After Eight Days	% Reduction Uncorrected	% Reduction Corrected
1 (20 cc)	268	37	18 (10)[a]	93.3	88.9
2 (40 cc)	312	41	18 (17)[a]	94.2	90.5
3 (Control)	198[b]	——	120 (34)[a]	39.4	——

[a]Numbers in brackets represent new or untreated burrow openings.
[b]Treatment consisted of covering with dirt only, no fumigant was used.

adjusted for the control calculated on the same basis. In reality the true values probably fall somewhere between these two sets of values. These figures were obtained by using the following formulas:

Formula 1 –

$$\frac{\text{No. of burrows treated}}{\text{No. of burrows in control (covered)}} = \frac{\text{Expected no. if no treatment}}{\text{No. of burrows re-opened in control plot (post-treatment)}}$$

Formula 2 –

$$\frac{\text{No. of burrows re-opened}}{\text{No. of burrows expected re-opened}} \times 100 = \text{Adjusted \% of squirrels remaining}$$

Formula 3 –

100 – adjusted % of squirrels remaining = adjusted % control

In addition to the earlier visual counts taken at 3, 4, 7 and 8 days after treatment and used to calculate the percentage of control, additional counts were taken at 14, 15 and 16 days after treatment to determine if possibly any squirrels which had been made ill by the treatment later recovered and became active. These counts were lower than the previous counts because the squirrels both inside and outside the treatment plots were trapped following the 8 day visual and burrow counts. The squirrels were removed with conibear No. 110 traps, as a follow up treatment. At the time of this trapping we had not planned on conducting a subsequent visual count two weeks after treatment. This second count was decided upon later to gain additional information. Plot 1 had seven squirrels removed from the census area and Plot 2 had five removed. As a result the counts taken approximately two weeks after the acrolein treatment and after the additional removal of squirrels by trapping were extremely low. No plot had more than one observed squirrel per any one scan. For the three days scans were taken, both Plots 1 and 2 averaged only 0.4 squirrels. This suggests that the affected squirrels do not become sick and hole up in their burrows to later recover and become active.

Visual counts of squirrels used for establishing the activity indexes only represent a small percentage of the squirrels actually in a plot, because they are not all above ground at any given time and some may be hidden behind vegetation from the observer. To give the reader some rough estimate of the population we would estimate that after 8 days each squirrel might re-open two burrow openings on the average. This would give estimated squirrel populations of 134 for Plot 1 (268÷2), 156 for Plot 2 (312÷2) and 99 for Plot 3 (198÷2). Another method might be to estimate 4 burrow openings per squirrel in old established systems. This would give 178 for Plot 1 (711÷4), 172 for Plot 2 (689÷4) and 93 for Plot 3 (370÷4). This would give a range of 134 to 178, average 156, for Plot 1, a range of 156 to 172, average 164, for Plot 2 and a range of 93 to 99, average 96, for Plot 3. At best these are nothing more than crude estimates of the starting squirrel populations and based on our experiences with ground squirrels, we believe these values are reasonable.

CONCLUSION

The lower application rate (20 cc) of acrolein was as efficacious as the higher rate. This degree of control (approximately 90%) by either activity index is excellent, and shows the material to be very promising.

Currently registered fumigants in California now consist only of gas cartridges, aluminum phosphide and magnesium phosphide (Salmon et al. 1982, Clark 1986). Burrow systems often have many openings, and each should be treated when using fumigants, therefore costs of materials can be very important. Currently the USDA-APHIS gas cartridges cost from 50 cents to $1.00 apiece and the use of commercially available gas cartridges can be even more expensive. Aluminum phosphide and magnesium phosphide tablets are approximately 15 cents apiece, and from 2 to 4 tablets are suggested per burrow opening. Acrolein if registered, used at the 20 cc rate should cost about 13 cents per burrow opening, making it more economical than the other fumigants. High application costs would, however, offset some of the lower material costs and the fact that acrolein must be applied by working hoses from a truck supply source.

Additional tests involving more replications of plots, comparing the efficacy of acrolein to other registered fumigants and perhaps testing lower doses of acrolein seem warranted.

ACKNOWLEDGMENTS

This study was assisted by many various agencies and individuals. Some that we would like to thank are the landowner, Coleman Foley, the Alameda County Agricultural Commissioner, Michael Greene and members of his staff who provided much of the labor and materials during this project, Earl Whitaker, John Gouvaia, Casey Jones, Jim Smith, Dave Reeve, Sonny Singh and especially Sharon Neklason and Damian Curry. Also Contra Costa County Agricultural Commissioner Jack de Fremery and some of his staff, Ed Meyer and Bart Hosman for supplying materials and equipment. Dave Blodget and Chet Gaddis from Baker Performance Chemicals, Inc. for supplying the acrolein and modifying the application equipment. My co-workers, Tom Patrick, Al Acosta and Ron Eng from the California Department of Food and Agriculture. Rex Marsh from UC Davis, for providing technical advise in setting up the study and reviewing the manuscript. And lastly, my wife Mary for helping me type the many drafts of this paper.

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