treated areas were close to untreated areas on the same trunks. On many trees, treated areas had almost complete suppression of sprouts while nearby untreated areas resprouted profusely (see photo). Only the picloram caused any leaf distortion of sprouts growing from treated areas.

Leaves and developing shoots in the tops of the trees, or on unsprayed areas of the trunks, showed no signs of hormone response or injury. Leaves and fruit from the olive and walnut trees, and leaves from the crape myrtle, were collected in mid-August, 1969, for residue analyses. Only 0.02 ppm (parts per million) of 2,4,5-T was found in the crape myrtle leaves. The allowed residue on crop plants for 2,4,5-T is 25 to 250 times greater. In walnut and crape myrtle, less than 0.02 ppm 2,4-D (which is the limit of the sensitivity of the analysis) was found. NAA analyses were not done because of the need for more sensitive procedures. Analyses to determine NAA residues in fruit will be performed on olive, and filbert from trees treated in 1971 with 1% NAA to control sprout development. Recently developed procedures for NAA are sensitive to 10 parts per billion.

The pruning wounds began to heal about the same regardless of the treatment, except for picloram on oleander and 2,4,5-T on crape myrtle. Around the pruning wounds of these species the bark was swollen and resembled crown-gall tissue.

Dormant applications to trees did not appear to be as effective in reducing sprouting as sprays applied after growth had begun. In both cases, shoots and leaves were removed from the treated areas. No recommendations can be made for these chemicals for sprout control on tree trunks pending registration for such use.

Northern California black walnut, sprouts pruned off trunk on March 13. Area in white rectangle sprayed with 1.0% NAA same day. Photo July 22, 1970. NAA had no effect on sprouting from untreated area on left.

Richard W. Harris is Professor, Roy M. Sachs is Professor and Robert E. Fissell is Staff Research Associate, Department of Environmental Horticulture, University of California, Davis. *Leaf and fruit specimens were analyzed by the Food Protection and Toxicology Center on the Davis Campus.*

CONTROL OF TREE ROOTS IN SEWERS AND DRAINS

O. A. LEONARD
N. R. TOWNLEY

Although tree roots in sewers and drains cause losses of millions of dollars each year in the U. S., there has been very little research on control methods. This is a report of 2½ years of chemical control tests in cooperation with the Sacramento County Department of Public Works. Two chemicals—metham (Vapam), and dichlobenil (Carsoron)—used alone, or in combination, killed roots in sewer pipes in one-hour-long treatments by soaking.

THIS REPORT involves studies of tests with chemicals for control of tree roots in sewers and drains conducted at Davis in a lathhouse and field work in problem areas of Sacramento County.

Plants used in lathhouse trials at Davis included eucalyptus, willow, grape, prune, peach, and cotton. The small trees were grown in plastic pots with holes punched in the bottoms. These pots were placed on top of other pots that were partially filled with sand or vermiculite. After the roots had developed extensively in the lower pots (three to 12 months), the lower roots were separated from the vermiculite and returned to these pots for a week or longer. Treatment was then made by soaking all except the upper 5 cm in the treatment solution, usually for one hour. The roots were allowed to drain before replacing the plants on the lower pots. In some experiments, the roots were sprayed rather than soaked. After returning the plants to the original pot assemblies, notations of injury to the roots and shoots were made periodically. The plants were broken out of the upper plastic pots after six to 10 weeks, and the entire root systems and stems were examined for browning and death of tissue.

Method used for treating roots of trees grown in lathhouse.

Fresh weights of the shoots, roots in the upper pots, and roots in the lower pots were measured in some cases.

Screening work involved all herbicides available that might be considered useful. Only two of the chemicals tested were sufficiently promising to be studied extensively: metham (Vapam) and dichlobenil (Carsoron), combinations of which are already being marketed for root control. Herbicides that were found to be ineffective in killing the soaked roots (1 hour soak) at 10 or 100 mg per liter included: paraquat, diquat, dinoseb, 2,4-D, 2,4,5-T, MBR-6033, CF-125, RP-17623, Eli-119, R-7465, CGA-10832. MSMA, cacodylic acid, bensulide, and endothall were ineffective at 1000 mg per liter. Picloram at 100 mg per liter, and 2,4-D and 2,4,5-T at 1,000 mg per liter killed roots but systemic injury ruled these materials out in our tests. Copper sulfate at 10,000 mg per liter killed the small roots of eucalyptus but new roots were formed one month later and were very abundant after four months.

An exploratory experiment using sodium hydroxide, with and without dichlobenil, was performed on eucalyptus and prune (table 1). The sodium hydroxide at 20,000 mg per liter was not effective in completely killing the roots of either prune or eucalyptus; however, it was less effective on eucalyptus than prune, probably because the roots were larger. Dichlobenil applied with sodium hydroxide appeared to have limited usefulness in retarding root regrowth on prune. However, sodium hydroxide clearly reduced the effectiveness of dichlobenil in killing eucalyptus roots. Treatment with metham alone, or in combination with dichlobenil, was effective in killing parts of roots that were soaked, as well as killing a few cm of untreated roots.

Metham is a consistant killer of roots of all species and the killing effect can extend well beyond the part treated. On the other hand, dichlobenil kills the roots of many species, but not all; further, the killing does not extend much beyond the portion actually soaked. The main advantage in a combination of the two herbicides is that dichlobenil markedly inhibits regrowth in lathhouse work.

Under some conditions, metham can cause systemic injury. Several factors involved in such injury include: concentration of chemical, time of soaking, rate of transpiration, and relative percentage of the total root system that is treated. A concentration of 500 mg per liter usually does not kill all of the treated roots, while a concentration of 10,000 mg per liter may cause systemic injury sometimes (with a 1 hour soak). A concentration of 2,000 mg per liter appears reasonably safe in field use. The abundance and kind of foliage is an important factor influencing both success in killing roots, as well as the hazard to trees when a large percentage of the root system is treated.

Four out of seven eucalyptus plants were killed in one experiment (5,000 mg

TABLE 1. EFFECT OF METHAM, DICHLOBENIL, AND SODIUM HYDROXIDE ALONE AND IN SOME COMBINATIONS ON KILL OF EUCALYPTUS AND PRUNE ROOTS*

Herbicide in mg/liter of water	Root kill†	Kill of root above point treated	Root regrowth into lower pot
	rating	cm	
EUCALYPTUS			
Metham 1,000 + dichlcbenil 100	10	4	none
Dichlobenil 100	10	3	none
NaOH	8	−16	–
NaOH 20,000 + dichlobenil 100	9	5	–
Check	0	–	–
PRUNE			
Metham 1,000	10	6	moderate
Dichlobenil 100	6	only small roots dead	–
Metham 1,000† dichlobenil 100	10	10	none
Metham 2,000	10	16	none
NaOH 20,000	9	−1	moderate
NaOH 20,000 + dichlobenil	9	−1	few
Check	0	–	–

* Lower roots soaked 1 hr. Root kill was determined 7 weeks later.

† Treated part of root (rating 0 to 10).

TABLE 2. EFFECT OF SPRAYING EUCALYPTUS ROOTS (WITH AND WITHOUT WETTING AGENT) ON KILL OF SUCH ROOTS, AS WELL AS KILL OF UNSPRAYED ROOTS IN SOIL IN THE UPPER POT.*

Treatment solution† Metham	Dichlobenil	Kill of sprayed roots	Root kill above sprayed roots	Kill of sprayed roots	Root kill above sprayed roots
		Without wetting agent		With 0.5% Triton X-100	
	mg/liter		cm		cm
Expt. 1					
10,000	200	not all dead	−6	not all dead	−10
20,000	400	dead	7		
40,000	800	dead	13	dead	2
Expt. 2					
40,000	800	dead	9	dead	4
80,000	800	dead	8	dead	9

* Records were obtained 7 weeks following the spraying. In no case were the shoots killed.

† Sprays applied with a USDA belt sprayer with the trees and roots in a horizontal position and sprayed once and allowed to drain. *Sprays applied with a 8004 Teejet tip @ 30 psi, 0.5 mph,* and a tip 6 to 10 inches from roots during spraying. Volume would be equivalent to about 42 gal/m of drain.

per liter with a 1 hour soak) when one-half or more of the root system was treated, while none of the 20 plants that had less than one-half of their root system treated was killed. Peach plants (which are more rapidly transpiring plants) were killed by the same treatment on one-third of their root system; while plants treated with 2,000 mg per liter for 1 hour were not injured when 1/5 of their root system was treated. This percentage would seldom be treated in the field. It should be recognized that small, lathhouse plants can be killed by a lethal transfer of metham from 15 to 18 cm, while such a transfer would be of no such consequence on large trees in the field.

Examples of tree roots plugging sewer lines in Sacramento County.

Spray trials

Spray trials were conducted because flooding of lines is not always desired due to the hilliness of terrain or the size of the drain (which could greatly affect chemical cost). Since there is commercial interest in spraying, two tests were conducted to learn just how effective spraying might be. The results in table 2 indicate that spraying can be effective, at least on lathhouse grown trees. Weaknesses in the spray method include the fact that the solution is not forced into cracks where roots are located or up home service lines which are often filled with roots. Soaking is the preferred method where it can be used.

Field experience

Field trials have been conducted in Sacramento County for a number of years but only during the past two years have the results been reasonably successful. In four treated areas of Sacramento County's sanitary sewer system involving a total of 75,637 ft, root stoppages were reduced from 50 to 100% for a period of six to 18 months after treatment. To insure that solutions will have uniform toxicity, a tanker is being built to mix the chemicals prior to placing them in the lines. In addition, a certain amount of "head" at the upper manhole is needed to drive the solution into cracks and up home service lines — which are often heavily filled with roots and can stop the trunk lines. A commercial preparation of "Vaporooter +" is being used, with a concentration of roughly 3,000 mg per liter metham and 200 mg per liter dichlobenil plus a wetting agent.

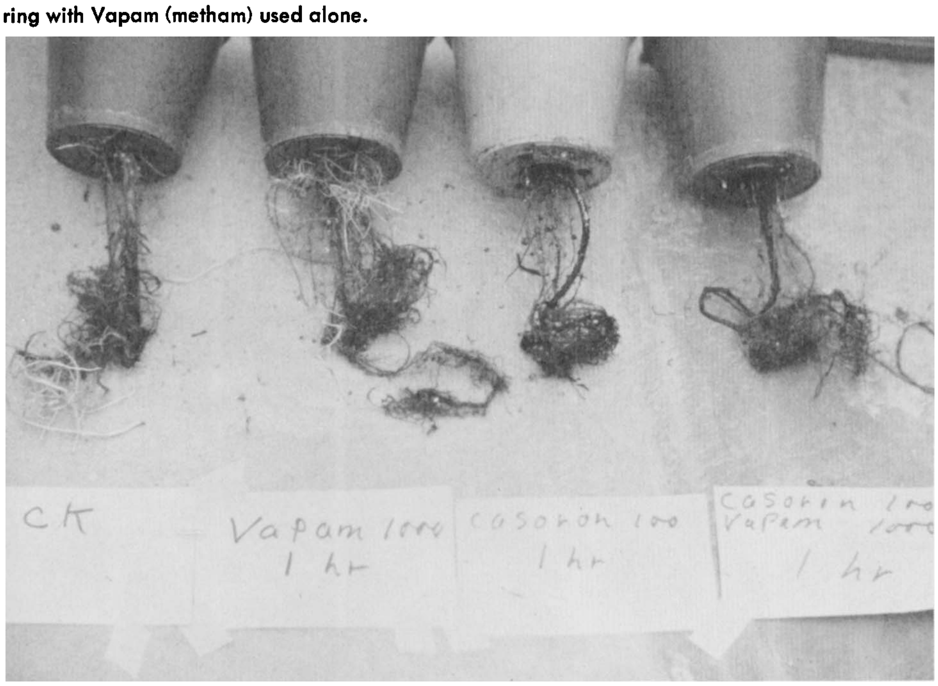
What could not be determined from lathhouse trials was whether similar treatments might be successful in the field—or the length of time control of roots might be expected. It appears that reasonable root control can now be achieved for at least 1½ years. There was no injury to shrubs or trees in the four areas mentioned. However, two shrubs were injured in an extensive trial this year.

The amount of chemical needed to treat perhaps 4,000 ft of line a day is very small compared with total flow in the sewage receiving plant. For example, 20 gallons of commercial preparation was used one day to treat 3,596 ft of line, while the receiving plant received a total flow of 4.9 million gallons during the same day. The chemicals are greatly diluted and have been undetectable to date in the receiving plants. No problems have been detected in the treatment process.

Results of spray application in the field did show root kill in the drains but some live roots were still in the joints. It would appear that with spraying, the treatments should be more frequent than with soaking. Spraying is considered a second choice in Sacramento County, except in large drains where cost of materials would be too great with the flooding method.

Field trials in the city of Sacramento with commercial preparations consisting of sodium hydroxide at roughly 12,000 mg per liter plus dichlobenil of about 130 mg per liter were successful in killing roots in lines of 3 mm diameter or less but did not kill roots in the joints. Soaking period was 1 hour. Metham alone or in combination with dichlobenil was far more effective in killing roots.

Root control experiment in lathhouse. Treatments all effective on eucalyptus but regrowth occurring with Vapam (metham) used alone.



O. A. Leonard is Lecturer and Botanist, Agricultural Botany Department, University of California, Davis. N. R. Townley is Senior Underground Foreman, Utilities Division, Maintenance Section, Sacramento County Department of Public Works, Sacramento.