CACODYLIC ACID AS AN ARBORICIDE

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Summary

Cacodylic acid has proved to be a comparatively safe and effective substitute for sodium arsenite in poisoning pines (*Pinus* spp.), when used in solution at high concentrations. At low concentrations, the acid is little more efficient than the Forest Service standard ammonium sulphamate solution when applied in bore holes, but is nine times more expensive.

INTRODUCTION

THIS PAPER summarizes the results of five trials in which cacodylic acid has been used at various concentrations in bored holes made in the lower stems of *Pinus radiata* and *P. patula* trees between 7 and 15 years old.

The Research Institute had been investigating arboricides since 1950 for use in chemical thinning of young conifer stands, where extraction of the produce was not justified. What was now sought was an alternative to ammonium sulphamate, which was safe to use but not as highly phytotoxic as desirable, and sodium arsenite, which was highly effective but banned on safety grounds. The initial trials with cacodylic acid coincided with the development of a powered tree-borer by a private forestry consultant. This machine could rapidly bore a hole to a depth of 5 in. in pines, into which a precise dose of arboricide could be injected by a reservoir-fed syringe. Both operations could be carried out almost simultaneously, preventing resin exudation from sealing off the wound. Poison absorption was rapid, poisoning could be carried out in wet weather with no fear of rain-wash or dilution, and there was no spillage.

PREPARATIONS AND PROPERTIES

CONCENTRATED SOLUTIONS

Solutions of 80% active and 65% active cacodylic acid were prepared at the Forest Research Institute for use with a motor-driven tree-borer. The method used was identical for both formulations: 1.2 kg of powder was placed in 1 litre of water at 80°F, and stirred vigorously for 15 minutes. Longer periods of stirring did not improve solubilities. When stirring ceased, insoluble material (assumed to be inert carrier) began to settle. Twenty-four hours' filtering through Whatman's No. 2 filter papers was needed to recover 1.5 litres of clear, slightly green, syrupy solution. These solutions are referred to below as 65% or 80% cacodylic acid, according to origin. The actual percentage of active ingredient in each solution was not determined. Both concentrations remained fluid and effective after one year's storage in screw-capped plastic flasks held at room temperatures, and also remained in good condition after two months' storage at 34°F.

Cacodylic acid is approximately equivalent to strong brine in its corrosive properties, and has lower toxicity to mammals than sodium arsenite. Although cacodylic acid is an arsenical, it is a non-cumulative poison. At high concentrations, cacodylic acid solu-

tions have a peculiar "dry" quality in contact with glass. One teaspoonful of detergent per gallon facilitated the use of these concentrated solutions in a glass-walled injector syringe.

LOWER CONCENTRATIONS

A 25% w/v aqueous solution of cacodylic acid was, at the time of the trials (January, 1964), available at a retail price in New Zealand of £6 10s. 6d. per gallon in a plastic container. This solution can be used through syringe injectors without any of the troubles initially experienced with the 65% and 80% solutions, but the manufacturers recommend the addition of a 1% non-ionic surfactant to achieve maximum effectiveness as an arboricide.

TRIALS AND RESULTS

TRIAL I

Trial I was established in December, 1962, in 15-year-old *P. radiata* in compartment 8a, Whakarewarewa Forest. Stocking was 390 to 440 stems per acre, pruned to 10 ft, of which 140 s.p.a. were selected for the main crop. Average breast height diameter was 9.7 in. and mean top height 82 ft. Ten trees were injected with 5 ml of 80% cacodylic acid per bore hole, and ten with 10 ml per bore hole. Trees up to 8 in. in diameter b.h. were bored once, and larger trees were bored twice to a depth of 4.5 in. Where there were two holes they were closely spaced externally, but were splayed tangentially. Within three weeks, all trees injected with 10 ml per hole were dead. At the end of this period trees injected with 5 ml per hole showed severe foliage scorching proceeding upwards through the crown, and in trees smaller than about 7 in. diameter, only the topmost whorls and leaders were unaffected. After another three weeks the foliage of all trees up to 10 in. in diameter was dead, and there was no subsequent recovery.

In simultaneous trials in this stand, a 90% sodium arsenite solution (diluted 1:2 parts water v/v), and ammonium sulphamate solution (15 lb per gallon of water) were also used. The 80% cacodylic acid compared very favourably with sodium arsenite, and was vastly superior to ammonium sulphamate in speed of top-crown kill. No side-effects attributable to root grafting, which was known to occur in similar stands near by, were observed with any poison used.

TRIAL II

Trial II was established in April, 1963, in unpruned, unthinned 11-year-old *P. patula* planted at 6 × 6 ft in compartment 48, Rotoehu Forest. Diameters ranged from 2 in. (suppressed trees) to 8 in. (dominants), and mean top height was about 70 ft. Seven hundred and sixty stems per acre were scheduled for thinning to waste, leaving 460 residual stems. A little diameter growth was still taking place.

The performance of 65% cacodylic acid solution was compared with that of the sodium arsenite and ammonium sulphamate solutions used in Trial I. The dosage and the number, spacing, depth, and angle of the bore holes were varied in different treatments. One row of trees was assigned to each treatment. Each row contained about 90 poisoned trees interspersed with main-crop trees and all the rows were contiguous.

Total dosages of 10 ml and 15 ml of the 65% cacodylic acid solution killed all foliage within 14 days, and doses of 5 ml applied in a single hole produced the same result within a month. Number, depth, angle, and position of the holes and diameter of the tree made no difference to the end result. The 65% cacodylic acid solution therefore gave very satisfactory results, comparable with those obtained with equal volumes of the sodium arsenite solution. Dosages of 15 ml and 10 ml of ammonium sulphamate gave a complete crown kill within two months, but after six months 5 ml per tree had killed only trees less than 5 in. in diameter.

In subsequent contract poisoning, generally good results were obtained by applying 10 ml of ammonium sulphamate solution in one bore hole to trees below 6 in. in diameter, and a total dosage of 20 ml in two holes to trees over 6 in. This indicates that the *P. patula* trees were very susceptible to poison, no doubt because they lacked vigour as a result of the high stand density. There was no sign of poison transmission in either trial or contract areas, and no evidence that root grafting had yet taken place.

TRIAL III

Trial III was established in December, 1963, in seven-year-old, unthinned *P. radiata* planted at 8 × 6 ft spacing on a steep slope in compartment 45, Rotoehu Forest. Diameters ranged from 2 in. to 9 in. Stocking was patchy on mid slopes, but the trial was confined to moderately well stocked areas.

Cacodylic acid 65% was used (a) at full strength, (b) diluted with water 50:50 v/v, (c) diluted 25:75, and (d) diluted 1:9. Cacodylic acid 65% was also used in mixture with saturated ammonium sulphamate solution in the proportions by volume of (a) 75:25, (b) 50:50, (c) 25:75, and (d) 1:9. Dosages were 10 ml, 5 ml, and 2 ml, syringed into one bore hole per tree. Holes were drilled to 4.5 in., at a 45° angle in a radial plane. One row containing about 20 poisoned trees was assigned to each treatment. Alternate rows were treated.

The only reasonably satisfactory results were obtained with 65% cacodylic acid undiluted with either water or ammonium sulphamate. Injections of 10 ml killed trees up to 5 in. in diameter within one month and trees up to 7 in. within two months of application. Larger trees, including full-crowned, vigorous co-dominants and dominant "wolf" and malformed trees, had their lower crowns defoliated but the upper crowns were unaffected. Results from lower dosages and lower concentrations of 65% cacodylic acid decreased in effectiveness in approximate proportion to the cacodylic acid content of the solution. Ammonium sulphamate was no more effective than water as a diluent.

In chemical thinning, stands of this type and age are more often encountered than well stocked 10- to 15-year-old stands, and are harder to poison successfully. Poison applied as solutions in bore holes generally moves upwards through the green crown. In young, fairly open stands, the lowest branches of the crown are the most vigorous and bear most of the foliage, and in consequence divert a considerable proportion of the ascending poison, often not leaving sufficient to reach and kill the top whorls and the leader. In older and more densely canopied stands, the most vigorous branches and foliage are confined to the upper crown, well above the poisoned holes.

Complete lower-crown kill is rarely achieved by bore-hole application in young stands, as there is insufficient length of unbranched

stem above the injection point to permit the spiralling poison to form a complete band around the stem periphery and to enter the base of the green crown evenly, so as to kill every foliage-bearing branch of each node. Splaying the bore holes tangentially may help, but success is more likely to be achieved by placing a highly toxic solution in a complete, or almost complete, girdle of shallow frill cuts.

This trial demonstrated that, when cacodylic acid is used in bore holes, only high concentrations hold promise for efficient tree poisoning.

TRIAL IV

Trial IV, using a commercial 25% cacodylic acid solution, was established in October, 1963, by the manufacturers in 8-year-old *P. radiata*, compartment 23, Te Wera Forest. In this stand, which was growing vigorously on moderate to steep slopes, there were about 250 s.p.a. Mean top height was 35 to 40 ft, diameters averaged 5 to 6 in., and the green-crown bases were approaching 20 ft. One row containing 20 trees to be poisoned was used for each treatment. There were nine treatments, and the tree rows were contiguous. Poison solutions were syringed into holes which had been bored about 18 in. above ground level with a power saw equipped with a wood-bit attachment.

The nine treatments were: 25% w/v cacodylic acid solution, with and without the addition of a 1% non-ionic surfactant, at 5 ml and 10 ml in one hole per tree, and 10 ml in each of two holes per tree; commercial ammonium sulphamate, 200 g in 100 ml of hot water, at 10 ml in each of two holes per tree; and a commercial arsenical weedkiller (As_2O_3 , 62.5% w/v) injected at 10 ml in one hole per tree, and at 10 ml in each of two holes per tree.

Results were recorded by A. K. Familton (N.Z. Forest Service) in April, 1963. There had been little change when the stand was inspected by Forest Research Institute staff in June, 1964. The cacodylic acid, with and without surfactant, had killed most of the suppressed and sub-dominant trees, but had only partially defoliated the larger crown classes without achieving a top kill. Effectiveness increased in approximate proportion to the volume injected. Initial results recorded by G. R. MacKenzie (N.Z. Forest Service) showed that the cacodylic acid solution appeared to be slightly faster in action with surfactant than without.

The results obtained with the cacodylic acid solution were generally very similar to those achieved by the ammonium sulphamate solution, volume for volume, and they were all disappointing. On the other hand, sodium arsenite solution was highly effective in producing a quick and complete crown kill, as might have been expected from the high volumes and concentration used.

In view of the satisfactory results of the earlier trials with 65% and 80% cacodylic acid solutions, it is plain that the 25% active commercial solution is not sufficiently concentrated to be an effective substitute, when applied at low dosage rates, for the highly efficient, cheap, but dangerous, concentrated sodium arsenite solutions formerly widely used by the N.Z. Forest Service, but now banned under current safety regulations.

CONCLUSIONS

- (1) In concentrated solution (70% or more active), cacodylic acid is an effective and safer substitute for the banned sodium arsenite, which was very effective and cheap, but highly toxic to mammals.

- (2) A compatible wetting agent or surfactant needs to be added to concentrated cacodylic acid solutions when glass-walled syringes are used for injection.
- (3) It is impracticable to prepare large volumes of concentrated cacodylic acid solutions from the powder form using filter papers.
- (4) The commercially prepared 25% aqueous solution of cacodylic acid has too low a concentration of active acid for effective and economical tree poisoning in chemical thinning operations, which depend on securing a quick and complete crown kill with the smallest possible volume of poison.
- (5) The commercial 25% preparation costs about nine times more than bulk-purchased ammonium sulphamate, but, volume for volume, is no more effective.
- (6) In young, vigorous pine stands, chemical thinning will probably be more effectively and conveniently achieved by frill, rather than by bore-hole applications of poison solutions, particularly if the poisons are highly phytotoxic. In older stands with a high green-crown base, thicker bark, and easy access to the stem, the bore hole technique is as efficient and very much quicker.
- (7) Concentrated cacodylic acid solution has considerable promise as a tree poison, provided the cost can be substantially reduced.

NOTE: The 80% active and 65% active cacodylic acid used in Trials I and II were Ansar preparations and were in the form of fine, white crystalline powders. They were kindly donated by Ivon Watkins-Dow (N.Z.) Ltd. The 25% w/v solution of cacodylic acid is manufactured by Ivon Watkins-Dow (N.Z.) Ltd., and sold under the trade name "Cull". The 90% sodium arsenite solution was I.C.I. "Weedex 90". (9 lb As_2O_3 per gallon.) The commercial sulphamate used in Trial IV was "Ammate X", and the commercial arsenical weedkiller used in the same trial was Murton's arsenical weedkiller.