PROTOTYPE EQUIPMENT FOR SOIL INCORPORATING GRANULAR AND LIQUID FORMULATIONS OF INSECTICIDES IN CONIFER SEED STANDS

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In a previous report (Fogal *et al.* 1981) we presented evidence that broadcast application of a granular formulation of carbofuran could successfully control spruce budworm on seed trees of white spruce *Picea glauca* (Moench) Voss (Coniferae: Pinaceae). However, carbofuran granules left on the surface of soil are attractive and toxic to birds (Barber 1979). Incorporation of a granular formulation of the insecticide into soil can significantly reduce bird mortality but trials in several orchards of the southeastern U.S.A. did not provide consistent control of target pests or increases in cone and seed yields (Barber 1979, Overgaard *et al.* 1983). Application of water by sprinkler irrigation to help dissolve granules enhanced insect control and further reduced the risk to birds (Hertel and Barber 1978), and sprinkling a liquid formulation was better than a granular formulation for control of cone insects on red pine *P. resinosa* Ait. (Coniferae: Pinaceae) (Rush and Overton 1987). Herein, we describe equipment that we have used to compare incorporation of granular and liquid formulations of carbofuran into soil for control of insects on seed trees of black spruce *Picea mariana* (Mill.) B.S.P. (Coniferae: Pinaceae) in small experimental plots (Fogal *et al.* 1988).

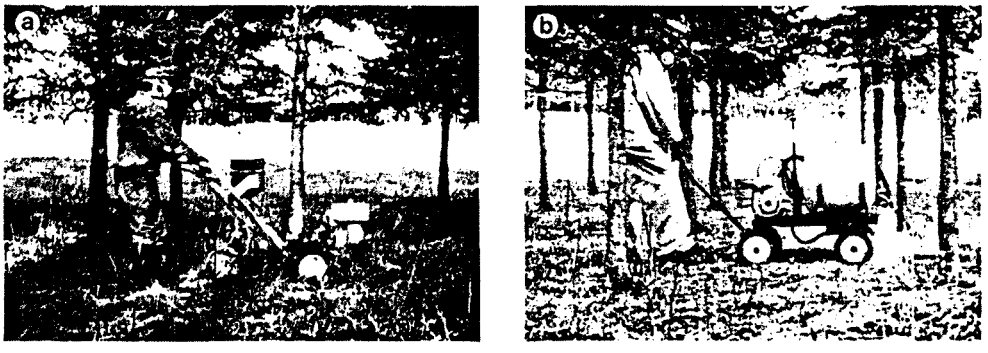

FIGURE 1. (a) Hoe drill and (b) sprayer in operation in a black spruce seed stand.

To apply the granular insecticide, a hoe-drill was constructed by modifying a 6 h.p. Rocket VI rototiller manufactured by Ariens Co., Brillion, Wisconsin (Figs 1a and 2a). Parts, denoted by letters, are shown on the line drawing (Fig. 1a). The rototiller attachment was removed and two Massey-Ferguson cultivator tines (part no. 1716448-MI) (L) and chisels (part no. 1903259-MI) (K) were mounted 60 cm apart on the rear of the tractor unit. This was accomplished by bolting a flat iron plate 1 cm x 15 cm x 75 cm across the end of the gear box to serve as a mounting plate (O). A second flat iron plate, of the same dimensions, was welded in a flat position parallel to the first mounting plate across the two angle irons to provide a mounting plate for the two cultivator tines (M). Chisels were welded to the cultivator tines (K, L). A hopper (A) from a fertilizer spreader (Imperial Roto Spread, Mark IV; manufactured by Erie Iron Works Co. Ltd., St. Thomas, Ontario) was mounted on the handles of the tractor after modifying the fertilizer release gate. The original control gate was removed. A copper pipe 10 cm long and 4 cm in diameter (o.d.) was cut in half longitudinally and one half soldered to the

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bottom of the hopper to create a trough (B). Two 1-cm diameter holes, 4 cm apart and 1 cm from the ends, were drilled through the bottom of the trough. The end of a 1-cm diameter (i.d.) polypropylene tube 35 cm in length was slipped over the copper tubes and extended to the upper part of the cultivator tines (F). Then, a copper tube 35 cm long and 1 cm in diameter (o.d.) was inserted into the bottom end of each polypropylene tube (H) and clamped onto the back of the cultivator tines so that it extended to 2 cm below the top of the chisel. Rubber tubing (1 cm, i.d.) (J) extending to the tip of the chisel was slipped over the end of the copper tubing; the lower end was cut at an angle, with the open side away from the chisel to prevent clogging of the tube with soil.

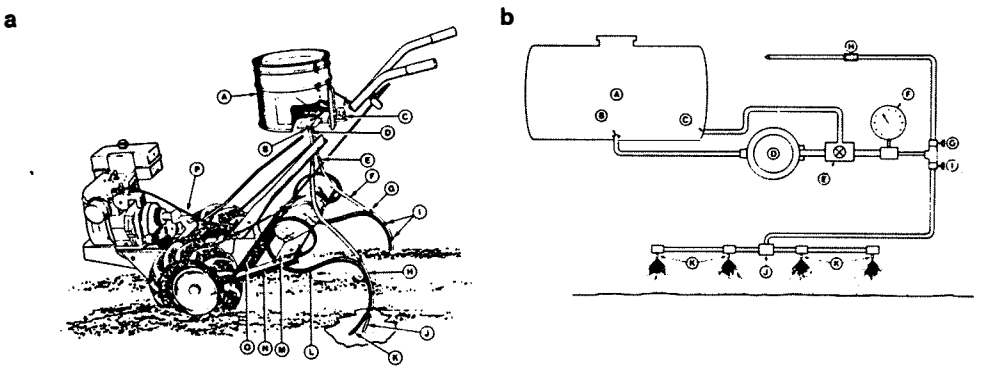

FIGURE 2. (a) Line drawing and cut-away of hoe drill: A, Hopper from a fertilizer spreader; B, modified gate, 4 cm copper pipe, cut laterally; C, control for opening gate; D, soldered copper tubing x 2; E, hose clamp; F, 1 cm (i.d.) polypropylene tubing; G, hose clamp; H, 1 cm O.D. copper tubing; I, large hose clamps for holding tubing; J, 1 cm (i.d.) rubber tubing, lower end cut to wedge; K, welded cultivator chisel; L, cultivator 'S' tine (Massey Ferguson); M, 1 cm x 15 cm x 75 cm iron plate for mounting tines; N, 5 cm x 5 cm angle iron; O, 1 cm x 15 cm x 75 cm mounting plate; P, garden tractor (Ariens, Rocket VI)). (b) Line drawing of sprayer: A, 85 litre polypropylene tank; B, outlet to pump, with screen; C, return to tank for agitating liquid; D, pump; E, control and bypass valve; F, Ashcroft pressure gauge; G, control valve to hand wand; H, hand wand; I, control valve to spray boom; J, t-fitting; K, nozzles with flat spray tips.

The gate control on the hopper of the hoe-drill permitted release rate adjustment by volume (100 mL was equivalent to 139 g of 10G Furadan). The two delivery tubes released equal volumes of granules and granule release volume was related to ground speed and gate setting in calibration trials under operating conditions. Thus, uniform application of insecticide was possible with varying treatment areas and insecticide application rates. The drill had adequate power to maintain a relatively uniform depth of 6 to 8 cm. Some damage to feeder roots occurred when they were snagged and broken or pulled to the surface by the cultivator chisels. That caused some impediment to forward motion, but the bouncing motion and vibration of the gasoline engine helped maintain a continuous flow of granules into the furrows. Low gear (23 m/min = 1.4 km/h) was found to be superior to the higher gear (42 m/min = 2.5 km/h) as better control of the machine could be maintained and fewer roots were brought to the surface. Furrows did not close completely following each pass so raking was required to cover any exposed granules.

A liquid formulation of carbofuran was applied as a soil drench with a modified motor-powered (3 h.p.) sprayer and tank mounted on a hand-pull wagon (Mighty Mac Sprayer, manufactured by Ameund Mackissic Co., Parker Ford, Pennsylvania) (Figure 1b and 2b). In addition to the original equipment, a 1.2 m boom was attached 20 cm above ground across the rear of the wagon. The boom was fitted with four shank nozzles (K) (two No. 9191A-531TD and two No. 9192A-531TD, TeeJet Spraying Systems Co., Wheaton, Ill.) for 12.7 mm (i.d.) hose. Nozzles were equipped with 65° flat

spray tips (no. 6503, TeeJet). The 15.9 mm (i.d.) feeder hose from the pump was joined to the 12.7 mm nozzle hoses by a reducing T-connector. Valves (E, G, I) were added to direct flow to the hand wand or boom, and to facilitate continuous mixing of the solution within the tank. A fine brass screen (B) was placed over the outlet in the tank to prevent clogging of the spray tips by dirt particles in the spray mixture. A pressure gauge (Ashcroft, No. J7363-5, J. Instruments and Specialty Co., Elk Grove Village, Ill.) (F) was placed between the multiflow valve (E) and the on-off spray control valves (G, I).

The sprayer was easily moved over most terrain. Rates of application were governed by the concentration of the solution, operating pressure, and forward speed. At a pressure of 276 kPa each nozzle delivered 1 litre of spray per minute. A boom height of 20 cm provided uniform distribution of spray mixture over the surface of the root-bearing soil and good penetration into the duff with minimum spray drift. Higher boom heights would have required higher pressures and resulted in greater drift, whereas a lower boom would have resulted in snags on stumps and debris. Speed was calibrated with a stopwatch held by a second person. With practice, a slow walk of approximately 33 m/min (2 km/h) could be maintained and delivery rates calibrated by varying the concentration of solution or by number of passes over a specified area.

The two units are easy to construct by modifications to available equipment and could be adapted for operational use in small orchards. The hoe-drill could be modified to reduce root snags by using chisels designed to cut through smaller roots and to ride over larger diameter roots. It could also be modified to deliver liquid rather than granules into furrows by utilizing components of the sprayer. Injection of liquid into the soil would likely improve uptake and efficacy of insecticide by comparison with granule incorporation (Fogal *et al.* 1988) and would also reduce deposits of insecticide on the surface of soil, litter, and vegetation that occur with a sprayer.

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