An evaluation of controlled droplet application (C.D.A.) hand-held sprayers for spot spraying

J.H. Combellack and R.G. Richardson
Keith Turnbull Research Institute
Vermin and Noxious Weeds Destruction Board
Department of Crown Lands and Survey
Frankston 3199, Victoria

SUMMARY

An evaluation of controlled droplet application (C.D.A.) hand-held equipment for spot spraying was made, and a modified sprayer suitable for Australian conditions is described. The motor performance characteristics of two types of sprayers were examined. The Micron 'Herbi' unit is fitted with a regulated motor that runs at constant speed over the range 4 to 15 v, while the Turbair 'Forester' unit has a motor the speed of which is related to supply voltage.

INTRODUCTION

Spot spraying of weeds, defined as "the treatment of weeds on an individual basis" is widely practiced in Australia. Combellack (1978) has estimated that 100 million ℓ of herbicide spray solution is applied annually by spot spray techniques in Victoria. The herbicide is usually applied in large volumes of water (up to 3000 ℓ/ha) and plants are normally sprayed until they are thoroughly wetted. This method is widely used, probably because high volume equipment was the first manufactured, and because it can be used to spray single plants or large clumps. Spot spraying systems have been described by Ripper (1956), Potts (1958) and more recently by Combellack (1978) who suggested that hand-held rotary atomizers could be used in Australia, particularly where drift control is esential or where weeds were growing in normally inaccessible areas.

Many papers have described hand-held rotary atomizer equipment and their performance (Bals, 1969, 1975; Matthews, 1976a, 1976b; Boize and Dombrowski, 1976; Johnstone et al, 1973a, 1973b; Rogers, 1975; Combellack and Shaw, 1977) but none has discussed their suitability as spot spraying systems. Recently it was found (Combellack and Harris, 1978; Combellack et al, 1978) that C.D.A. equipment using specially formulated herbicides (Shaw and Combellack, 1978), produced variable, but none-the-less encouraging results when used for spot spraying.

This paper describes in detail the controlled drop application (C.D.A.) equipment that has been assessed for spot spraying and examines the performance of motors from two C.D.A. sprayers.

EQUIPMENT

Three C.D.A. hand-held spraying units have been tested viz.

Micron 'Herbi'*, Turbair 'Forester'**, and Union Carbide 'Sevin'***. So that the 'Herbi' could be used for spot spraying the Micron 'Ulva' feed tube was fitted to the 'Herbi' head. This placed the spray reservoir above the rotary atomizer so that plants up to 2 m in height could be sprayed. The modified unit will be called the 'SS Herbi' in this paper.

All spray units were of similar design. A toothed atomizer disc approximately 80 mm in diameter is driven by a small 6 or 12 v DC motor mounted in a plastic housing. Herbicide is supplied to the disc by a feed tube and nozzle mounted on the motor housing. The 'SS Herbi' and 'Sevin' are powered by eight 1.5 v D cells carried in the handles of the units. The 'Forester' is powered by two 6 v lantern batteries mounted on the end of the handles.

The feed tube, which incorporates a screw thread for the herbicide reservoir is moulded into the plastic body of the 'Forester' and 'Sevin'. The 'Forester' is fitted with a brass orifice that meters herbicide to the rotary atomizer, while the orifice in the 'Sevin' is an integral part of the body moulding. In the 'SS Herbi' the feed tube can be fitted with nozzles of different diameters. This allows the flow rate to the rotary atomizer to be varied. On the 'SS Herbi' a small breater tube is fitted to let air into the herbicide reservoir. With formulations tested in the field this had a tendency to block. The 'Forester' and 'Sevin' depend upon air leaking along the threaded portion of the reservoir, which proved to be very effective under field usage.

The rotary atomizers on the 'Forester' and 'Sevin' sprayers are composed of pairs of dished discs joined together by three plastic spacers on the 'Forester', and five on the 'Sevin'. The outer disc is toothed while the inner disc or splash plate is not. This leads to a range of droplet sizes because, although satellite droplets are virtually eliminated from the sharp needle points of the outer disc, they do occur from the blunt surface of the splash plate (Bals, 1969). Also, liquid builds up around the spacers and flows off the disc as filaments which results in a wide range of droplet sizes. The 'Sevin' with fine spacers is worse than the 'Forester'.

The 'SS Herbi' has a single cup-shaped rotary atomizer which is grooved on the inside edge to provide an even flow to the peripheral serrations. This rotary atomizer produces a much narrower droplet range than the other two discs.

When spot spraying, herbicide must not drain into the motor when the unit is turned over to cut off the supply of spray to the atomizer. The 'SS Herbi' has the best protection with concentric mouldings on the disc and housing. The 'Sevin' has a small plate between the motor and disc which is not effective, and the 'Forester' has nothing.

Available from:

* Micron Sprayers, Three Mills, Bromyard, Herefordshire, U.K.

** Turbair Ltd., Britannia House, Waltham Cross, Hertfordshire, U.K.

*** Union Carbide Aust. Ltd., St. Kilda Road, Melbourne, Victoria, Australia.

Handles on spot sprayers, ideally, should have a hand grip about 4 cm in diameter which allows a firm grip as the machine is constantly being turned over. Both the 'SS Herbi' and 'Sevin' sprayers had excellent handles, but the 2 cm diameter grip of the 'Forester' was too small. Also, the plastic grip on the 'Forester' tended to slip which made the machine difficult to handle.

Balance and weight of the units is quite important, especially when spraying tall weeds. The 'Forester', with its batteries at one end and the motor and spray reservoir at the other, was well balanced. However, this advantage was somewhat negated by its weight which at 4.50 kg is heavier than the 'Sevin' (3.46 kg) or the 'Herbi' (2.43 kg). All weights are for the unit with batteries and the reservoir filled.

Overall length of the unit is important when spraying bushy weeds. The 'Forester' and 'Sevin', at 1.85 m length, are ideal for Victorian conditions but the 'SS Herbi' at 1.55 m was too short. Length of unit for transport is also important. The 'Forester' is hinged and folds to about 1 m length, but wires in tube were often damaged by the hinge. To fold the 'SS Herbi' the batteries must be removed. The 'Sevin' has a moulded plastic thread to join the battery holder to the extension tube. This is, undoubtedly, the best system.

The "on/off" switch is easy to reach and is positive on the 'Sevin'. The 'Forester' has a good switch which is difficult to reach while the 'SS Herbi' switch is poor as it is not sufficiently positive.

The 'Forester' is constructed of zinc-coated steel tube and the 'Sevin' is made of moulded mild steel. Both are robust, although the 'Sevin' may be susceptible to corrosion. The 'SS Herbi', which has a plastic battery holder and aluminium extension tube, is thought to be too frail for constant field use in Australia.

Motor performance tests

The size of droplets produced by a given rotary atomizer is dependent on the angular velocity of the atomizer (Bals, 1969), on the flow rate of liquid to the atomizer (Boize and Dombrowski, 1976), and on the type of liquid used (Johnson et al, 1977). Thus the relationship between battery voltage, load on the motor, and motor speed should be known. Twenty-five 'SS Herbi' motors and 21 'Forester' motors were tested. The 'Sevin' motors were not included because their high speed made then unsuitable for herbicide application.

The motors were removed from the housings, fitted with atomizer discs supplied with the motors, and then mounted in a stand with a nozzle supplying water containing 0.05% of a non-ionic surfactant (Nonidet WK) onto the disc. The load on the motor could be varied by using a flow rate to the disc of either 0, 1 or 3 ml/sec. Each motor was connected to a variable direct current source. An ammeter was connected in series with the motor and a volt meter across the motor terminals and the speed of the motor was measured with a stroboscope.

The speed of the 'Forester' motor was dependent on the voltage supplied (Figure 1) and as flow rate to the disc increased at a given voltage the motor slowed down. Figure 2 shows that increased power is needed to drive the motors at higher speeds and to atomize increasing amounts of liquid.

In comparison the 'SS Herbi' motor has a regulating mechanism so there was little variation in motor speed over most of the voltage range examined (Figure 3). At 3 ml/sec load there was no variation in motor speed from 4 to 15 volts. The motors were also very uniform, all running at exactly the same speed. Power consumption increased with increasing load and applied voltage (Figure 4). Similar results were found by Johnson et al (1977).

The characteristics of the C.D.A. motors influence the type of batteries that would be most suitable in the field. With the 'Forester' motors it is obvious that batteries must have a fairly stable voltage output over most of their lifetime, (e.g. alkaline cells) or that conventional batteries must be discarded when motor speed drops and unacceptably large droplets are produced. The 'SS Herbi' motors, however, only require dry cells with an acceptable lifetime.

The 'SS Herbi' is equipped with eight 1.5 v cells in series (i.e. 12 v). From Figure 4 it can be seen that slightly less power would be used if the batteries were connected in series and parallel to give 4 to 5 volts. Unfortunately, the handle configuration of the 'SS Herbi' unit does not permit this arrangement.

CONCLUSIONS

The ideal hand held C.D.A. sprayer should have the following features:-

1. It should be of durable construction and resistant to corrosion.
2. To enable the spraying of tall weeds its overall length should be at least 1.8 m.
3. For easy transportation the unit should break down so that the maximum length is 1.2 m.
4. The battery tube or hand grip must be 4 cm in diameter.
5. The power source should be readily available, e.g. U 2 torch batteries.
6. The on/off switch must be easy to locate and be positive.
7. The motor should use minimum power, be regulated to run at constant speed, and be well sealed.
8. The rotary atomizer should have a toothed perimeter and be of the single disc type to reduce the production of satellite droplets.
9. The feed tube orifice must be changeable so that the flow rate can be varied with formulations of different viscosity.
10. The reservoir should be of 1 to 1.5 ℓ capacity and have a snap fit connection to the feed tube to allow for quick refills.
11. The overall weight of the unit should not exceed 4.5 kg when filled.

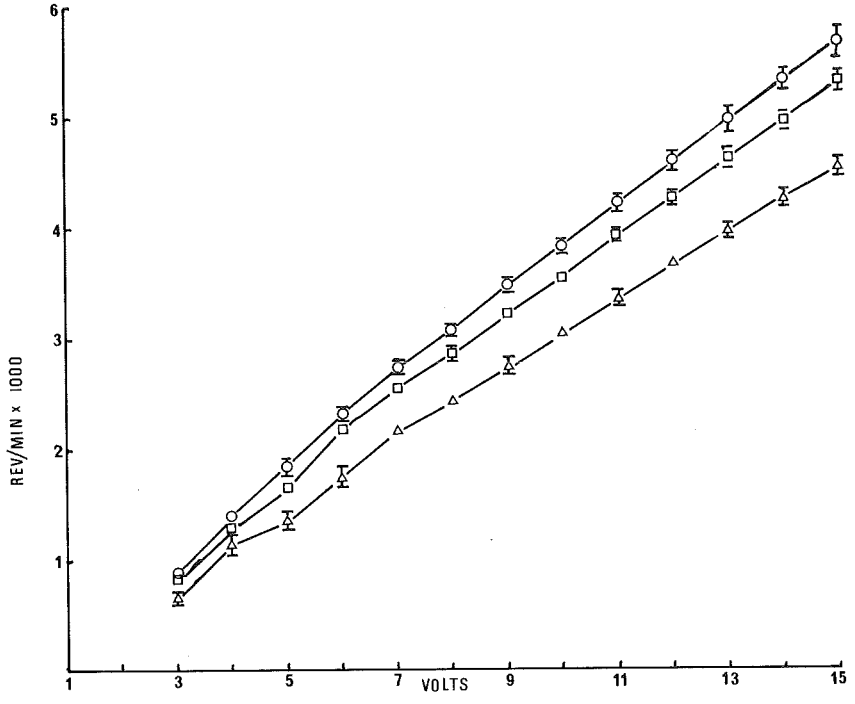

Figure 1. Effect of varying voltage on speed of 'Forester' motors under zero load (O), 1 ml/sec (□) and 3 ml/sec (Δ). The 95% confidence intervals are shown where they exceeded the size of the point.

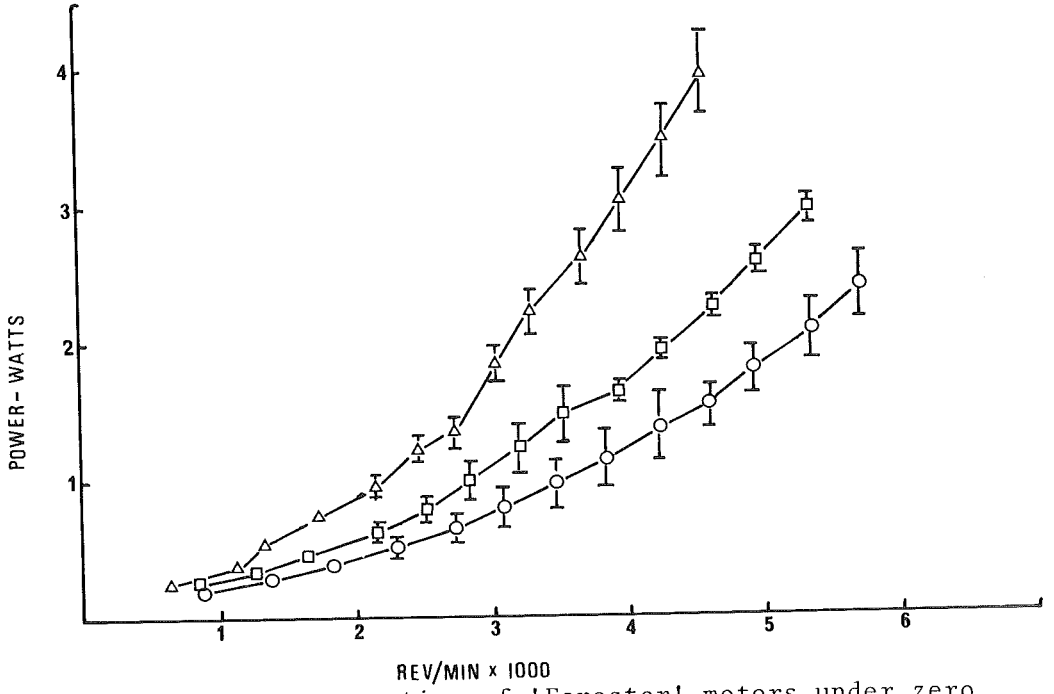

Figure 2. Power consumption of 'Forester' motors under zero load (O), 1 ml/sec (□) and 3 ml/sec (Δ). The 95% confidence intervals are shown where these exceed the size of the point.

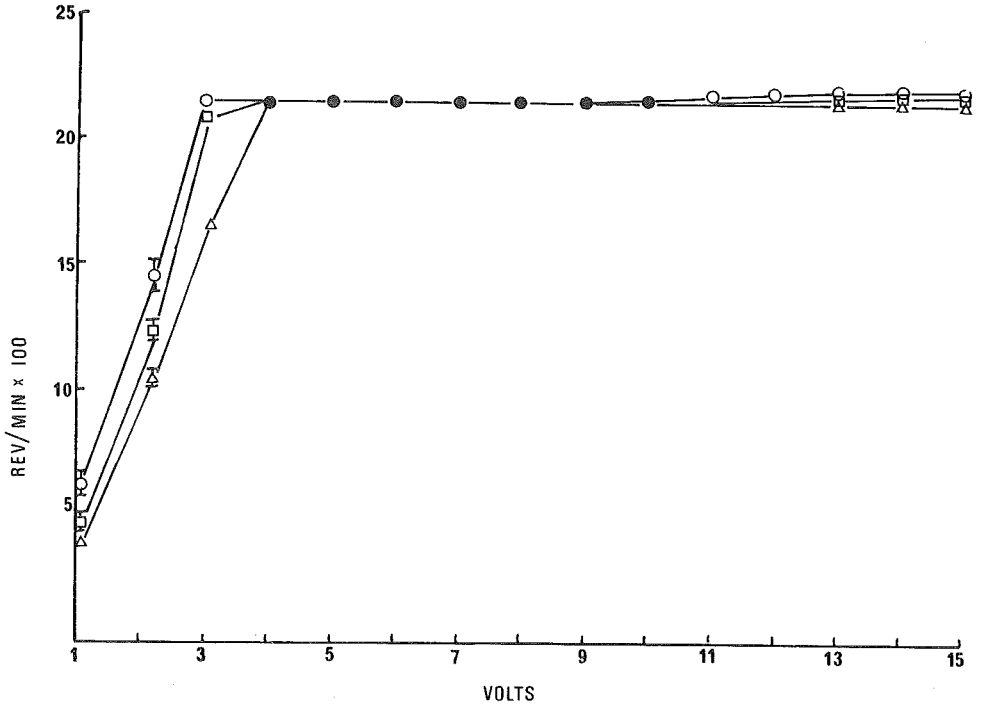

Figure 3. Effect of varying voltage on speed of 'Herbi' motors under zero load (O), 1 ml/sec (□) and 3 ml/sec (Δ). The 95% confidence limits are shown where these exceed the size of the point.

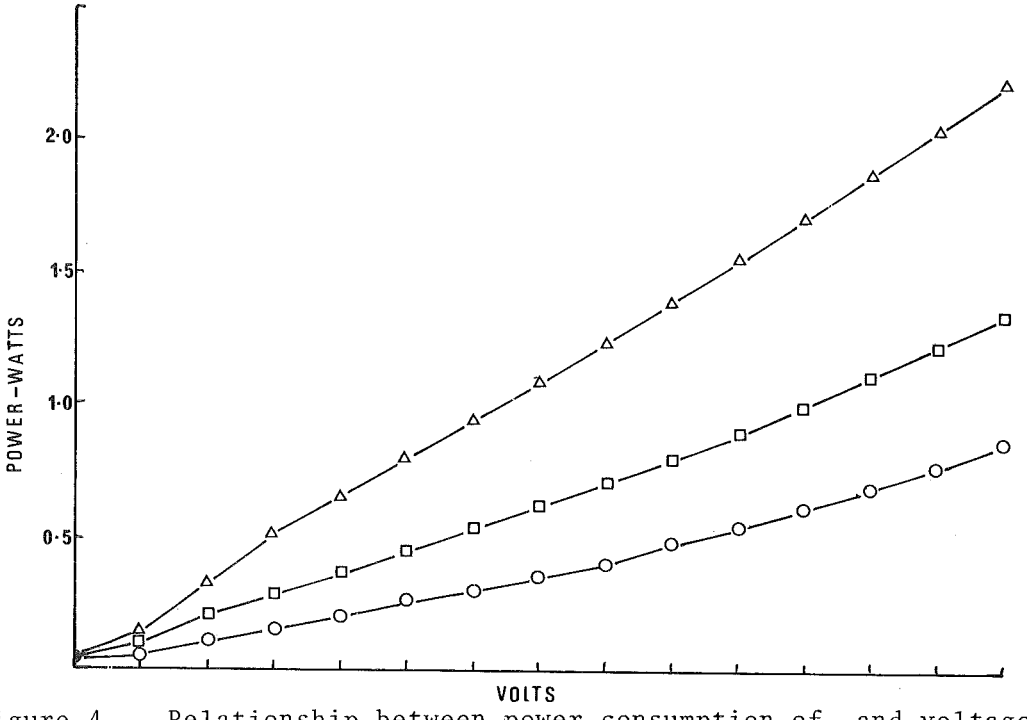

Figure 4. Relationship between power consumption of, and voltage applied to,'Herbi' motors under zero load (O), 1 ml/sec (□) and 3 ml/sec (Δ). The 95% confidence limits lie within the boundary of the points.

In view of these requirements a compromise machine is considered the best available C.D.A. system. This consists of a 'Sevin' battery holder and extension tube, a 'Herbi' head, motor and rotary atomizer with an 'Ulva' feed tube and reservoir attached to it.

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