Aerial spraying of herbicides

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SUMMARY

A brief description is given of types of spraying equipment as fitted to aircraft.

To determine the best total spray volume for any weedicide application, the optimum droplet size and plant cover must be known. Although smaller spray droplets may improve herbicide efficacy, the factors of recovery, penetration and drift must be considered.

INTRODUCTION

Can the chemical be applied by aeroplane? This is the question often asked when a new herbicide is being discussed. It immediately places the aircraft in a greatly differing category from earthbound machinery, and reinforces many myths and unknowns of their operation; because, despite its acceptance as a regular means of applying herbicides, there still exists an air of mystique surrounding the aircraft.

The truth is, of course, that almost any herbicide can be applied by aircraft. The success, or otherwise, of the application depends on a multiplicity of factors, many of which are common to all types of spraying equipment. This paper attempts to explain these different factors, so that the weed worker will have a greater understanding of aerial spraying. The agricultural aircraft is thus brought down to earth.

APPLICATION EQUIPMENT

The most common liquid dispersal equipment used on aircraft is the conventional boom fitted with Tee-jet atomizers. The jets may be either hollow cone or fan-type and spray pressure is within the range of 140 to 280 kPa. Apart from the somewhat larget jet sizes employed and assymetrical nozzle placement across the boom, a typically equipped spraying aircraft could well be described as a flying boom spray. Indeed, it is only after emission from the nozzle jets that differences become apparent. It is the introduction of the spray mixture into the 100 knot airstream and the influence of the aircraft's airframe, which are responsible for these differences.

Some Australian aerial operators use rotary atomizers to apply insecticides and fungicides. The most successful of these is the "Micronaire" which consists of a spinning cage into which the spray mixture is metered. When rotation speed is high, the resulting average droplet size ejected from the periphery of the cage is smaller and more even than from conventional atomizers. The requirement for such small droplets (less than 100 μ) is usually a disadvantage in herbicide applications. Reasons for this will be explained later. The further and more important disadvantage of the "Micronaire" in herbicide application is the unevenness of the spray deposit across the swath, which occurs at normal spraying heights due to the small number of discharge points.

For agricultural chemical applications, fortunately, there is not the requirement for complete continuous coverage with high volumes. Indeed, in the typical boom spray operation, plant cover is unlikely to approach even 50% of total plant surface and may be satisfactory at as low as 0.5% with systemic chemicals. One of the primary factors influencing the cost of an aerial spraying operation is the volume and type of carrier used on each hectare. If we therefore accept that partial cover is satisfactory for herbicide treatments, it will be useful to know exactly what the minimum and/or optimum cover requirement would be for any particular treatment.

DROPLET SIZE AND DROPS PER UNIT AREA

These two criteria are essential in determining spray volume.

(i) Droplet size

There has been considerable work carried out on droplet sizes of insecticides applied in different situations. There must be almost complete agreement that when the same amount of active ingredient is applied per hectare, efficiency of control increases as droplet size decreases.

The situation with herbicides is not so conclusive. Much of the work carried out with phenoxy acetic acid herbicides has yielded results which have been contradictory. Ashford (1974) reports that spray applications of 2,4-D to weeds in wheat produced similar results with 200 and 100 μ droplets. Hurtt et al (1969), reported that effects of 2,4,5-T on tree seedlings was about five times greater for the 125 to 250 μ range compared with 500 μ droplets.

These results conflict with work done by the Canada Department of Agriculture (Wilson, 1977), using 2,4-D applied to sunflower seedlings. With all combinations of spray volumes and drop sizes, it was shown that three to six times the active ingredient was required for 200 and 400 μ droplets, compared with 100 μ droplets. A comparison of ultra low volume (U.L.V.) and conventional spray equipment using 2,4-D by Lugg and Roberts (n.d.), showed superior results with U.L.V. on a range of weeds. The droplet mass median diameters (M.M.D.) were 68 and 250 μ respectively.

Other workers such as Behrens (1957), reported that there was little difference in 2,4,5-T activity with droplet size when applied at a constant volume to cotton seedlings. An extensive study was made on a range of herbicides by Buehring et al (1969). Paraquat had optimum herbicidal efficiency with droplets of 400 to 500 μ range. Diuron, fluometron, amitrole and MSMA, showed no variation in activity at normal rates of application.

(ii) Drops per unit area

This is the other important data requirement in determining optimum or minimum spray volume for maximum herbicidal efficiency.

There has been limited work carried out in this area. Fisher et al (1956), applied 2,4,5-T to mesquite at volumes of 5.5 to 45 ℓ/ha, while maintaining a droplet size of 200 μ. There was no significant difference in control achieved. Behrens (1957) concluded that when applying 2,4,5-T to cotton, maximum efficiency was achieved with a density of 11 droplets per cm^2, or greater. Such density is easily achieved. The Victorian Vermin and Noxious Weeds Destruction Board carried out aerial trials in Gippsland to determine suitable spray volume when treating ragwort with 2,4-D (Schmidl, 1964). Although this trial demonstrated better weed control with reducing spray volumes, no record was made of droplet size or deposit densities.

Apart from any relationship between droplet size, density and herbicidal activity, there are other important factors which may override selection on these bases alone. These include penetration in thick foliage, recovery and drift.

PENETRATION

Aerial spraying is economic only at relatively low total spray volumes. In order to achieve satisfactory coverage of the target and penetration into thick foliage, atomization to produce fine droplets is essential. Percentage cover of a range of droplet sizes is shown in Table 1. Small droplets will penetrate more readily into a dense crop than will larger droplets because they will not impinge on the large upper surfaces of the leaves of the crop.

Table 1. Droplets per unit area and % area covered at 12 ℓ/ha

Droplet size	Drops/cm^2	Flat surface % cover
50 micron	1528	4.76
200 micron	24	1.19
1000 micron	0.2	0.24

Droplets larger than 200 μ fall to the ground or deposit on the other foliage. At the other extreme, droplets of less than 50 μ are capable of reaching all parts of the plant and settle onto lower leaves, the undersides of leaves, plant hairs, etc. This feature is more important in treating small hidden insects than in spraying weeds.

Indeed, it is this impingement onto plant hairs, etc., which may reduce direct contact with many herbicide treatments. Also, most herbicides are applied in situations of early pasture or crop growth, where overall plant cover is low.

RECOVERY

Recovery is usually expressed as a percentage; it is that portion of the total spray volume which finally reaches the target. The three main components of chemical loss between the aircraft and the target are evaporation, vertical drift and horizontal drift.

Evaporation depends on relative humidity, and the volatility of the chemical and its carrier. If the spray mixture is volatile, then the basic factor in evaporation is the surface to volume ratio. This ratio , and with it the rate of evaporation, increases as the droplet becomes smaller and is very significant once the diameter of the drops falls below 150 µ. One accepted method of reducing evaporation is to use a less volatile carrier such as oil, in place of water. Ultra low volume applications make use of low or non-volatile materials. In selective weed control it is important to ensure that the carrier is not phytotoxic and that its use does not result in a loss of selectivity in the crop.

Vertical drift loss occurs in unstable air conditions, and is worst after midday and during the warmer period of the year. The air mass is regarded as unstable when the lapse rate or decrease in temperature with height exceeds that of the standard "3°C per 1000 feet" Unstable air is exhibited as thermals or general turbulence. Under these conditions many small spray droplets are carried aloft and never reach the target area. This explains the large losses of non-volatile U.L.V. materials, especially when applied at greater than normal spraying heights.

The loss of spray material due to horizontal drift is greatly overrated; the exception is perhaps in small inaccessible treatment areas, which should not be sprayed in strong winds. The loss of chemical due to conventional drift, regardless of wind strength, is significant not to the owner of the crop being sprayed, but to his neighbour downwind of his crop.

All three major components of chemical loss will be lessened by adopting the largest droplet size possible.

DRIFT

Some cultivated crops are many times more susceptible to weedicides than the weeds being treated. This means that very small quantities of spray drifting downwind from target areas can have disastrous consequences. When spraying weedicides in the vicinity of susceptible species, consideration of drift must take precedence over all other factors.

Unfortunately, many of the same conditions which are suited to high recovery and weedicide efficiency may also be the conditions most conducive to drift. The best summaries on how to minimize drift appear in papers by those prolific workers and writers Akesson and Yates

Temperature inversion - When the temperature of an airmass increases with height, a temperature inversion exists. Under these conditions, the usual mixing of air at different levels is restricted. While this does not significantly lower chemical recovery in the treatment area when sprayed from normal heights, it will allow fine droplets to drift uninterrupted horizontally if a light breeze is blowing at the time. Yates, Akesson and Cowden (1974) measured chemical residues 0.8 km downwind to be 13 times greater during very stable conditions (temperature inversion) compared with neutral conditions. This means that, contrary to popular belief, potential drift is greatest during many early mornings and late evenings, when a light breeze occurs, and is less when strong winds are present to prevent the existence of an inversion.

Atomization - Chemical residues collected 0.8 km downwind in the same experiment were 5.5 times greater when the aircraft was fitted with hollow cone spray jets to produce the smallest droplets possible, compared with the same aircraft equipped to produce the largest possible droplets.

Hence it can be seen that drift is reduced as droplet size increases, which is the same requirement providing high recovery. Because it is not possible at this time to produce all droplets of a given size, our approach to drift control is to increase the average droplet size or M.M.D., in order to lessen the volume of drift-prone droplets (below 100 µ). When controlled droplet application is achieved, we will be able to use smaller M.M.D's. (the aim will be 150 to 200 µ), which will also suit both high recovery and high herbicidal efficiency.

CONCLUSION

It is obvious that in practice the optimum droplet size will be a compromise between required droplet density needed for optimum weedicide efficiency, and that required to avoid excess drift and loss of recovery. Most herbicides used in broadacre work can be applied by aircraft as long as a few basic principles are observed.

We should get rid of old prejudices and hangups about aircraft application. Foremost amongst these would be the belief that the best method is to spray with wheels in the crop and in calm weather. Another is the "3 gallons per acre" syndrome employed by some chemical companies. To specify a volume on the label with no mention of droplet size or density for a particular situation immediately indicates a lack of basic research. Agricultural operators and pilots also experience guilt feelings regarding lowering of total spray volumes. Providing the resultant droplet density is sufficient for weed control, there is no crime in reducing your cost of operation and hence the cost to the client.

When the requirement is for high density and large droplet application, we should forget about aircraft. For instance, application of bipyridals onto the spring flush of pasture growth should not be attempted within the present limits of an aircraft's ability. We should spray non-translocated post emergent chemicals in the very early growth stage, so that droplet density will be sufficient for satisfactory plant cover. The greatest weather ally in maximizing recovery is low temperatures - the greatest ally of drift is a temperature inversion associated with a light breeze.

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