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Progress in the development of controlled drop application of herbicides

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The WRO contribution to the development of controlled drop application (CDA) was reviewed in the 1974–75 WRO Biennial Report (Taylor & Holly, 1976). Since this last review, there has been growing awareness of the need to raise the often deplorable standard of operation of conventional spraying equipment (Rutherford, 1976), to re-appraise existing methods of applying herbicides, and to encourage new approaches to the application of agricultural chemicals.

Controlled drop application has been defined as the production of sprays with a drop size spectrum controlled to a greater extent than is possible with conventional hydraulic nozzles. In practice, most interest in CDA has centred upon the reduced water volumes that, without undue risk of drift, the technique makes possible. Thus, at WRO, we have worked within a closely controlled drop-size-range of 150 to 350 μm, and with volumes of 3 to 50 l/ha in contrast to the 200 to 300 l/ha commonly applied through hydraulic nozzles.

It is now widely realised that the reduction in spray volume consequent upon the introduction of CDA could enable much better use to be made of the limited time available to the cereal grower to apply the ever-increasing quantity of crop protection chemicals required to maximise yields. The logistic advantages are such that low volume methods of application are likely to be commercially successful even if they only achieve existing standards of chemical performance although, clearly, improved performance would be a desirable attribute.

WRO has made a significant contribution to the agronomic development of CDA but this needs to be seen in the context of the increasing volume of research activity elsewhere, from the fundamental studies at NIAE to other agronomic work by ADAS and by commercial companies. In addition, substantial progress has also been made at WRO in investigating the effects of herbicide concentration, formulation, deposition, and environmental factors on the plant response to controlled drop application. However, this article reviews only the agronomic research on this topic which has taken place at WRO and elsewhere in the last two years.

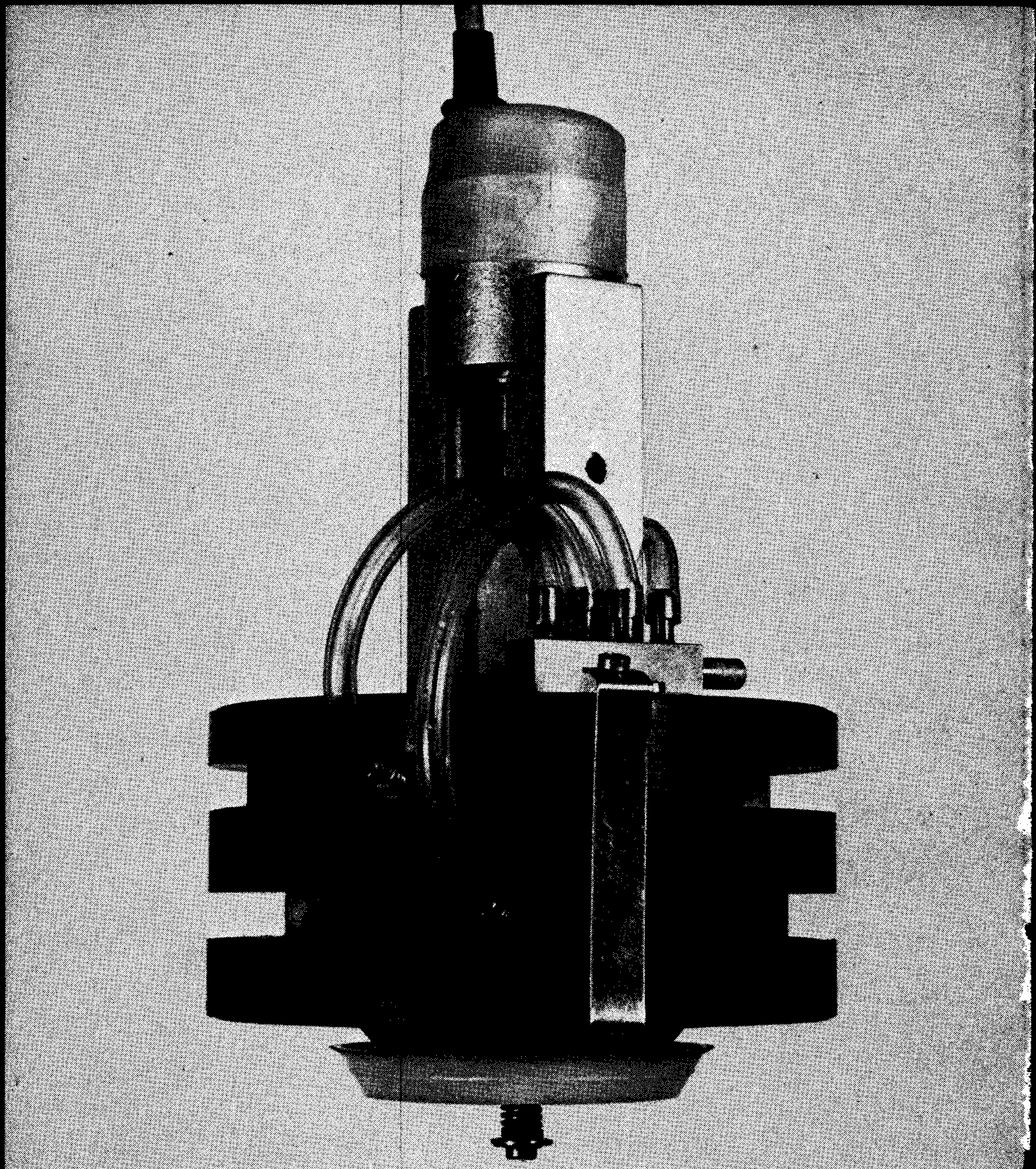

Fig. 1. This controlled drop application unit, initially designed and built at WRO, comprises three rotating discs, the upper two shrouded, the lower fully exposed. Units of this type are used on an experimental sprayer now produced by Cropsafe Ltd. Speed of rotation, and hence drop size and flow rate, can be monitored and controlled easily and accurately.

RECENT DEVELOPMENTS IN EQUIPMENT FOR CONTROLLED DROP APPLICATION

The 1974–75 WRO Biennial Report described the experimental spraying units developed at WRO in 1974/75 using the 'Herbi' discs, developed by Micron Sprayers Ltd., stacked vertically to achieve adequate throughput and shrouded to even out the horizontal distribution. These formed the basis of a tractor-mounted experimental sprayer for the treatment of large field plots. For the 1976 programme of field experiments we employed modified units developed and loaned to us by Horstine Farmery Ltd., embodying twin discs of which the upper disc only was shrouded, the liquid being fed on to these discs by gravity. These proved a success but required considerable care and experience to ensure accurate application. For the 1977 experimental programme therefore a new unit was developed collaboratively by WRO and Cropsafe Ltd. embodying three discs stacked vertically, the upper two being shrouded and the lowest one unshrouded (Fig. 1). This machine incorporated control of disc speed and flow rate of spray liquid and was thus versatile and accurate enough for experimental use. Concurrently, Horstine Farmery Ltd developed a wide-boom field sprayer employing a similar configuration of stacked and shrouded discs. This is now under commercial development as the Micro-drop sprayer.

All of this equipment embodied the same basic principle of direct drop formation. Drops are produced immediately from the circumference of the 'Herbi' disc within a very narrow spectrum of drop size. This system has the advantage that drop size can be closely defined and controlled, and also varied for experimental purposes. The main disadvantage is that direct drop formation occurs only at relatively low flow rates. Greater flow rates can be achieved by employing the process of ligament drop formation but the control of drop size is not then so precise. However, this process can reduce the number both of very large and inefficient drops and of the very small drift-prone drops, characteristic of hydraulic nozzles. Currently, both NIAE and Micron Sprayers Ltd are working on the development of a rotary atomizer based on ligament formation and the latter has now produced a new cone-shaped unit operating at higher flow rates. So far we have no information on the performance of this interesting device.

FIELD RESULTS WITH CONTROLLED DROP APPLICATION

Over the past 7 years we have completed over 200 experiments on pot-grown plants and over 70 experiments in the field comparing the performance of a range of herbicides applied conventionally and by CDA in volumes ranging from 5 l/ha to 100 l/ha and at drop sizes ranging from 150 μm to 350 μm.

The results of this extensive programme of work support the general conclusion that herbicides, as they are formulated at present, fall into three categories of behaviour in relation to low volume CDA applications.

(i) Herbicides showing an improved performance at very low volume controlled drop application. The best example in this category is glyphosate, which in pot and field experiments at WRO has shown a consistent trend to improved performance, generally of the order of 25–30% (Caseley *et al* 1976; Turner & Loader 1978). Although all our experiments included doses below those which are normally recommended, we have never been able to show the dramatic improvements in herbicide performance which have been claimed elsewhere for other crop protection chemicals.

(ii) Herbicides the performance of which remains substantially unchanged. It appears that most soil-acting herbicides, and those foliage-applied herbicides which are efficiently translocated throughout the plant, exhibit this response. We have worked extensively with the broad spectrum mixtures of MCPA and dicamba, with barban, and with tri-allate and other soil-acting materials (Ayres 1976; Ayres & Merritt 1978; May & Ayres 1978; Merritt & Taylor 1977; Taylor & Merritt 1974 (2); Wilson 1976; Wilson & Taylor 1978). Chemical companies have also had extensive experience with these materials, with growth-regulator herbicides, and with benzoylprop-ethyl, flamprop-methyl, etc. (Mayes & Blanchard 1978; Robinson 1978; F. R. Stovell, *pers. comm.*; O. Grosjean, *pers. comm.*). To date (May 1978) some 30 herbicides have been cleared under the Pesticides Safety Precautions Scheme for application at reduced volumes of 20–50 l/ha and with a controlled drop size of the order of 250 μm. A number of companies are developing commercial recommendations for these materials.

(iii) Herbicides showing a definite reduction in performance with very low volume controlled drop application although frequently giving an acceptable level of control. Into this category we must place those herbicides which have been consistently poorer in performance or unpredictable in their response to CDA. Our experience is largely with ioxynil and bromoxynil, with or without dichlorprop, but other evidence suggests that phenmedipham, bentazone and benazolin may also be reduced in activity at these very low volume rates (Cussans & Taylor 1976; M. J. May, *pers. comm.*). Difenzoquat is rather inconsistent in its response, sometimes giving better and sometimes much poorer performance (particularly in the summer of 1976) than when sprayed with conventional equipment (Wilson 1976; Wilson & Taylor 1978).

In general, the results which we have achieved in the field at WRO have been confirmed by those obtained by many chemical companies including The Boots Co. Ltd., Shell Chemicals (UK) Ltd., Union Carbide Ltd. There have, however, been some discrepancies between our results and those of ADAS (Bailey 1978).

THE DEVELOPMENT OF LIGHT-WEIGHT, LOW-GROUND-PRESSURE VEHICLES

The suggestion that the use of lower spray volumes with a consequent lower payload requirement could lead to the development of special purpose light-weight spraying vehicles was first put forward by Cussans and Taylor (1976). Such vehicles should be able to travel at speeds greater than are possible with normal tractors so that increased output could be maintained. In close collaboration with NIAE and their ADAS Liaison Officer, a number of small, rough-terrain transport vehicles were examined for this potential. Two vehicles were chosen, one equipped with tracks and the other with eight low-pressure tyres. A granular applicator was mounted on the tracked machine and a conventional boom with hydraulic nozzles on the wheeled vehicle. It was the latter which was used most extensively in the winter of 1977. A photograph appears on page 61. Nearly 20 ha of winter wheat and barley were treated with isoproturon or chlortoluron and limited applications of clofop-isobutyl were made to winter oats. This experience rapidly confirmed the potential of vehicles of this type. Spraying speeds of up to 20 km/h were shown to be feasible and herbicides applied in volumes of 60 l/ha gave excellent weed control. Even at these high speeds, boom stability was excellent and, most impressive of all, access was possible onto wet soils on which normal tractors could not possibly have worked.

FUTURE PLANS

Controlled drop application is now progressing steadily towards commercial exploitation and all concerned with herbicides have to face the implications of this for new and existing materials. In the past year we have already seen the development of one completely new atomizer and, with the interest this has generated throughout Europe, one can expect that there will be more to come. Our work with low-ground-pressure vehicles suggests that we shall have to accept that speed is a variable parameter of spraying comparable to pressure, nozzle size, drop size and other factors of atomization. The possibilities for future research are great and of growing complexity. However we shall continue, so far as we are able, to contribute towards the advancement of the agronomy and weed science of this complex though fascinating subject.

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