THE DEVELOPMENT OF A SYSTEM FOR THE IN-FIELD EVALUATION OF BOOM SPRAYS.

R.B. DOYLE

Dryland Research Institute
Department of Agriculture
Merredin W.A. 6415.

Summary: A three year project, entitled "The Evaluation and Development of Crop Spraying Efficiency in Cereal Crops" was commenced in 1982. The work to date has centred around the establishment of an analysis system that will provide information as to the in-field performance of the equipment used to apply herbicides. The analysis is split into two sections; an analysis of uniformity of application across the spray width and an analysis of the droplet deposition on horizontal and vertical surfaces within the crop.

INTRODUCTION

The increase in use of herbicides in Western Australia has been quite spectacular with some $48 million being spent on herbicides alone in 1983. Any improvement in efficiency of application will have a definite financial benefit.

The move towards direct drilling and very wide seeding equipment means that large areas are planted in a short space of time. This requires high capacity spray equipment, not only to keep ahead of the seeding equipment in the direct drill situation, but also for subsequent post emergent applications. An analysis of a hypothetical case illustrates the problems that exist. Take a situation where a farmer has dry sown 2000 ha of crop before the opening rains. The optimum time to kill weeds is between the 2 and 5 leaf stage. In good growing conditions this could be a period as short as 10 days of which only 3 days may be good for spraying. With an effective spraying period of 10 hours per day (which is above the average achieved) with a 20m boom spray the unit must travel at 33 km hr^{-1} to cover the area in the required period.

Quality water is a scarce commodity throughout much of the wheatbelt and, along with the need to keep the equipment moving, has led to the present low volume, high speed application techniques. The low average yields in the area have also squeezed the margins to an extent where many farmers reduce the chemical rates as well as the water rates. The average water rate is now around 40L ha^{-1} applied at an average speed of 16 km hr^{-1} though some operators are down to 17L ha^{-1} with conventional equipment and operate at speeds of up to 28 km hr^{-1}. With the introduction of a new machine this year the speeds will increase up to 40 km hr^{-1} and some CDA systems are being operated with the water rate reduced to as low as 5L ha^{-1}.

PRELIMINARY INVESTIGATION

Initial investigations sought to establish the fields of activity of other people, or establishments, involved in spray related research both within Australia and overseas. The relevance of this work to the situation that exists

in the wheatbelt of Western Australia was assessed.

Nozzle Testing: This is an area of investigation that has received a great deal of attention in the past few years. Modern testing techniques to measure droplet size have become very sophisticated with the introduction of laser differaction techniques (Combellack and Matthews, 1981). This equipment is now in use in Australia at the Keith Turnbull Research Institute of Frankston, Victoria. A duplication of this facility seems unnecessary, particularly when the high cost and level of funding are considered. Nozzle distribution characteristics have been investigated, using patternators (Andrews and Byass, 1977). This method collects the output from a single or series of nozzles over a period of time and divides the output up into sections of the spray width. This is a static test, and its correlation to what occurs in the field at high speed is not known. Some work has also been done in the Western Australian Department of Agriculture to investigate the uniformity of locally used nozzles.

Drift: Considerable work has been conducted world wide on the control of spray drift, to reduce the off target damage to susceptible plants. This problem has not been considered to any great extent in the wheatbelt due to the predominance of the wheat crop. The increased area being planted to lupins and increased drift of knockdown herbicides have brought the problem to light in recent years. Within the terms of this project the drift question will be approached from the point of improving application efficiency, which by definition will reduce losses, including drift.

Swath Matching: Wide equipment is the order of the day in the eastern wheatbelt of W.A., and one of the perennial problems with wide equipment is that of swath matching. The problem has in the past been analysed (Lawrence, 1977), and some attempts have been made to improve driving accuracy (Butterworth and Butterworth, 1981). No completely satisfactory system exists for broadacre farming at the present time, and farmer reaction indicates swath matching to be one of the big areas of concern.

Boom Oscillation: The high speeds of operation used in the wheatbelt provide for a different form of boom movement from that experienced at lower forward speeds. Boom movement is an occasional, violent action with the majority of the movement being of a high frequency vibration. Considerable investigation has been carried out on this problem (Nation unpublished). The high operational speeds prevalent in the W.A. wheatbelt merit some further investigation of this problem, to determine the degree of variation in droplet deposition due to the nozzle movements.

PROGRAMME DEVELOPMENT

Fluorometer: The aim of all broacre spraying operations should be to achieve a uniform application of the chemical to all parts of the spray swath. Where variations in application occur there will either be an area of poor kill, where insufficient application has been made, or areas of over-application. It would appear that despite the variation in application rate across the width, there is little stripping effect, and this would seem to indicate that even the low dosage areas are receiving adequate chemical while the remainder is being over-sprayed. Where the aim is to reduce application to a minimum, a pre-requisite must be to achieve a uniform application across the swath. A system to analyse the deposition across the swath has been used in South Australia where Richardson of Roseworthy College has been evaluating the performance of aircraft sprayers for

a number of years. The method used there, using fluorescent dyes sprayed over paper tapes, seemed to be applicable for the basis of a system. The utilization of fluorescent dyes has drawbacks if a defined value for the application is required. Where only a comparison of application rate is required, then the technique is quite sound. This system will enable the effect of different nozzle arrangements and equipment designs, to be evaluated for optimum in-field performance.

The system for evaluating the exposed paper tapes is based on a Sequoia - Turner Fluorometer model 112 with Strip Scanner door. The strip scanner has been modified to incorporate a long tape feed system that moves the tape through in 1cm increments. The advance mechanism is constructed from a converted Hannimex 2000 slide projector, and the rate of advance of the tape and the data storage are controlled by a programme developed by Dalgleish of the Applied Chemicals Research Unit at Frankston. The result obtained is equivalent to a patternator evaluation but is achieved under full speed field conditions. As the required result is a comparative analysis of the application across the width of the boom, the fading characteristic of the fluorescent dye is of no consequence provided the exposed rolls are stored in the dark in stable temperatures (Sharp, 1974).

Digitizer: The size and distribution of the droplets applied, along with their concentration, determines the effectiveness of the herbicide application. To better understand the mechanics of chemical activity some form of post-application droplet distribution analysis is required. A computerised droplet analysis system that transfers droplet data from a microscope to the memory of a computer via a digitizer tablet provides a simple method of obtaining and processing the required data.

This system is used to measure the stains that remain on Crystalcote targets and record the relevant data. It can also be used to collect the same data from fresh leaf specimens.

The specimen to be analysed is placed on the stage of an Olympus BHS 313 microscope fitted with a Reflected Light Fluorescence Attachment (BH-RFL-W4) and a drawing tube (BH2-DA). Over the specimen a graticule divided into 100 by 1mm squares is placed instead of a cover slide (this allows for the logical examination of a 1 sq cm area). Below the drawing tube is placed a Houston Instrument Hipad Digitizer that is connected through to a North Star Advantage computer. The cursor of the digitizer can be seen to be superimposed on the specimen viewed through the microscope, and data can be transferred direct to the computer. The programme used was originally developed for use in Medicine in analysing blood constituents. Using this system the base data from the trials can quickly be transferred to the computer and then the data manipulated into the form required.

Questionnaire: To establish the present sprayer performance situation a questionnaire was drawn up and circulated in the Merredin district.

Table I.

Sprayer size/are covered

Boom size	Sprayed area in hectares		
	Minimum	Maximum	Average
10m	400	1000	667
15m	200	7000	1182
20m	580	14000	3155

The results, presented in Table I show the variation in equipment size with hectare, and the average performance figures are presented in Table II.

Table II.

Questionnaire results

Average figures for the 98 farms:	
Area sprayed	2292 hectares
Speed for spraying	16 km hr^{-1}
Time for filling sprayer	13 minutes
Number of fills per year	51

FIELD EVALUATIONS

On these days a number of machines would assemble at a convenient meeting point for evaluation. First a static nozzle check was conducted, where the output from each nozzle was measured over a 30 second time interval, with the unit operating at normal operating pressure. For the ground wheel driven sprayers a PTO driven rolling road was used. The speed of rotation of the wheel being matched to the normal operating speed of the unit, as indicated by the operator. The measured output from each nozzle is plotted on the same scale as the printout from the fluorometer to indicate areas of reduced application.

The unit was then part filled with water, to which Rhodamine B dye was added at the rate of 10g to 50L. Once well agitated it was run over a set of paper tapes, held in metal tracks at normal operating speed. The paper is smooth finished 46mm wide adding machine paper and was held both vertically and horizontally to obtain deposits on both upwind and downwind vertical surfaces as well as the upper horizontal surface. At the time of crossing the tapes the wind speed and direction, temperature, humidity and barometric pressure were recorded as well as the speed of operation of the sprayer. The deposits on the tape are visible to the naked eye, and variations in droplet size and density give an immediate indication of problems with the sprayer. This has proved to be a very good talking point with the farmers present and has been a good extension exercise. As soon as the droplets were dry the tapes were rolled up and kept in a dark place until evaluated on the fluorometer.

During the 1983 season 35mm by 45mm Crystalcote cards were spaced out along the spraying width to collect sample droplets in both vertical and horizontal positions. Subsequent use of these cards has been restricted to trials where comparisons of chemical effectiveness are to be made, with full follow up biological assessment.

CONCLUSIONS

The fluorometer analysis system provides an accurate analysis of the uniformity of application from a boom spray and will be used as a basis for the evaluation of improvements in boom design. The digitizer analysis of impacted droplets has the potential to provide some of the answers as to why certain applications are more successful than others in replicated trial work.

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