POTENTIAL OPERATOR EXPOSURE TO INSECTICIDES: A COMPARISON BETWEEN KNAPSACK AND CDA SPINNING DISC SPRAYERS

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ABSTRACT

Spray treatments were undertaken in cotton and blackcurrants to compare operator contamination when using a high volume Lever Operated Knapsack (LOK) sprayer with hand lance held in front of the operator and a low volume Controlled Droplet Application (CDA) spinning disc sprayer (the ULVA+). Despite using a more concentrated spray mix, the ULVA+ gave significantly lower levels of contamination ($p > 0.001$) in these trials. Most contamination with the LOK sprayer occurred due to operators walking through airborne spray or treated foliage which the ULVA+ technique avoids. Practical suggestions are made to minimise operator contamination with both types of sprayer.

INTRODUCTION

Operators of manually carried sprayers are required to work in close proximity to spray emissions thereby increasing the risk of contamination during the spraying operation. The potential for exposure will largely be determined by the type of sprayer, crop characteristics and practices adopted by the operator and is a critical variable in assessing the degree of risk posed to spray operators during the spraying process i.e.

Degree of Risk = Exposure x Hazard (potential of pesticide to cause harm)

Although manually carried sprayers are widely used in developing agriculture, suitable protective clothing is often not available and is, in any case, frequently impractical for use in hot climates (Tunstall and Matthews, 1965). Furthermore the level of operator training and awareness of the potential risks involved in working with pesticides is often inadequate. This has given cause for concern and a desire to establish safer working practises. The most commonly used manually carried sprayer is the Lever Operated Knapsack (LOK) sprayer with hand lance. The use of such sprayers can, however, be laborious due, in part, to the requirement to fetch and carry large amounts of water to the fields as this often has to be transported some distance, particularly in semi arid regions.

An increasingly widely used alternative to knapsack sprayers in the tropics are battery operated spinning disc sprayers (Cauquil, 1987). These apply minimal volume rates by using relatively even sized droplets of the appropriate size for the target - a technique referred to as Controlled Droplet Application (CDA). Larger drop sizes of around 200-300µm are typically used for CDA herbicide treatments at 10-30 l/ha as a placement technique to avoid drift. For insecticide and fungicide spraying smaller droplet sizes are normally used at volume rates of 1-20 l/ha compared with 150-300 l/ha with knapsack sprayers thus significantly improving workrates. With this technique droplets are dispersed by wind and gravity onto the target surface. Specific Ultra Low Volume (ULV) oil based formulations were initially used (drop size 50-100 µm : volume rates 1-3 l/ha). This technique, however, has now, been largely superseded by Very Low Volume (VLV) spraying using standard water miscible formulations (drop size 75-150µm:volume rates 10-20 l/ha) e.g. over 1.3 million hectares of cotton in West Africa are now treated with the VLV technique. VLV spraying offers improved flexibility allowing for a wider choice of products and control strategies to be employed (Clayton, 1992). As the spray mix is more concentrated than that used with knapsack sprayers, a series of trials were undertaken to assess the levels of operator contamination with each technique.

There are four potential sources of operator contamination during the spraying process:-

- contact during mixing, filling and cleaning
- contact with airborne spray material
- contact with treated vegetation
- contact with leaking or contaminated sprayer parts

This paper discusses trials in cotton in Côte d'Ivoire and blackcurrants in the U.K. using knapsack and spinning disc sprayers. The objective was to examine the contamination occurring under actual field conditions and propose practical measures to minimise this.

MATERIALS AND METHODS

Spray Equipment:

Two types of sprayer were examined, a conventional LOK sprayer with single hand lance and the ULVA+ spinning disc sprayer. The LOK sprayer used hollow cone nozzles with flowrates in the range 500 - 750 ml/min at pressures of ~ 3bar (300 kPa). The ULVA+ was set to produce drop sizes in the range 100-120µm VMD (Volume Median Diameter) using 5 batteries and flowrates of around 150 ml/min as used for VLV treatments (Clayton, 1992).

Field Methodology:

Spray operators were dressed in disposable 'Tyvec' or cotton suits with gloves and face masks and a fluorescent dye incorporated into the spray mix to analyse spray deposits. This dye could be extracted from the various suit sections, gloves and mask filters and the deposit quantified with the aid of a spectrofluorimeter. The experimental techniques used were similar to those outlined earlier in Thornhill *et al* (1995) and Merritt (1989) and comply with recent guidelines issued for operator exposure studies (Chester, 1995).

Simultaneous spray treatments were made with either the LOK or ULVA+ sprayers in mature cotton and blackcurrants of 1.0 -1.4m height. In Côte d'Ivoire spray treatments were made by local farmers in cotton on plot sizes of 400-1000m^2 with the LOK sprayers and 3000-5000m^2 with the ULVA+. The difference in plot size reflects the increased workrate with the VLV technique as spraying started and finished at the same time with each sprayer. Similar plot sizes were used to compare treatments in the U.K on a 5 ha blackcurrant crop. Spray treatments with both the ULVA+ and LOK sprayers were generally made at right angles to the prevailing wind direction. Adjacent plots were separated by at least 20m to avoid any cross contamination. Windspeeds were typically between 0.8-2.2 m/sec for all treatments with temperatures of 25-30° C in Côte d'Ivoire and 18-22° C in the U.K.

Two fluorescent tracer dyes were used during these trials; sodium fluorescein and Helios OB (Ciba-Geigy, Basle, Switzerland). Sodium fluorescein is a water soluble dye and was used at concentrations of 0.5-1.0 g/l with water + 0.1% Agral 90 surfactant for high volume LOK applications and 5-10 g/l in water for ULVA+ treatments. Trials in Côte D'Ivoire also used Helios OB as an emulsifiable concentrate formulation. This allowed qualitative assessments to be made using a UV lamp to illuminate actual spray deposits on the operator. A photographic record of the spray contamination could then be made. For each paired treatment the same fluorescent tracer was always used with each sprayer. Spraying generally took around 5-15 minutes and thereafter spray deposits were allowed to dry on the various suit, gloves or mask surfaces. A sample of the 'tank mix' from each sprayer was taken immediately after treatment and a 100µl of spray solution transferred onto a section of unsprayed material using a micropipette. This sample was left in sunlight for approximately the same period as the spray treatments and subsequently used as a known standard for fluorimetric analysis. Recovery of the spray dye from the various suit sections is generally over 90-95 % (Merritt 1989) although this can depend on the exposure to sunlight, the sample substrate and extraction procedures used. Such variations are therefore minimised by preparing a known standard under similar conditions to the actual samples.

Laboratory methodology:

Spray deposits were extracted from the various materials using either water and 0.02 M NaOH solution for fluorescein dyes or a 90:10 mix of Acetone and Hexane solvents when using the Helios dye. Samples were left for around 1 hour in solution being agitated routinely throughout. A sample of each dye solution was then transferred into a cuvette from which a reading could be taken with a spectrofluorimeter (Sequoia Turner model 450). The instrument was calibrated using known concentrations of dye solution.

RESULTS

Results are expressed as the mean amount of spray material recovered from various parts of the body in µl per litre of spray applied or parts per million (ppm). i.e. as a proportion of the total volume applied. From this a direct comparison of contamination levels can be made irrespective of differences in volumes applied (refer to Tables 1 and 2 and Figure 1).

e.g. A contamination level of 100µl/litre applied = 100 ppm = 0.01%
Thus applying 300g a.i. /ha would theoretically equate to:-
300g x 0.01% = 0.03g or 30mg a.i. on the suit section.

The results in tables 1 and 2 are fairly similar although the levels of contamination were marginally higher in cotton. With the LOK sprayer the majority of contamination occurred on the front of the body, particularly the legs, thighs and lower abdomen. Much of this contamination is due to operators having to walk through the treated foliage and can be avoided in some situations by simply holding the spray lance downwind in the adjacent row (refer to results in Figure 1 with LOK 2 treatments - taken from recent work in Pakistan).

Table 1. Operator contamination in cotton on different parts of the body (µl/litre of spray applied - mean of 6 replicates)

Sprayer Type	Hood (1200)	Mask (172)	R Arm (1350)	L Arm (1350)	Gloves (900)	R Leg (1250)	L Leg (1250)	Rthigh (1900)	L thigh (1900)	F torso (2750)	R torso (2750)	F abdo (3550)	R abdo (3550)
	Body Area (cm²)												
ULVA+													
mean	9.3	0.05	63.1	133.0	33.6	11.9	21.3	13.1	6.1	33.9	30.4	39.7	65.8
Std Dev.	13.2	0.1	80.5	218.2	39.6	8.8	20.4	17.5	8.8	15.2	38.6	54.5	109.3
LOK 1													
mean	45.6	3.2	322.5	191.0	269.4	444.3	416.2	413.3	383.2	209.3	45.7	477.4	139.7
Std Dev.	65.7	1.8	137.8	82.1	69.2	98.0	91.9	116.8	88.7	91.9	36.6	160.3	48.1
LOK 2 *													
mean	1.8	0.7	29.7	76.3	23.6	62.7	42.6	52.6	45.9	60.9	26.2	25.0	38.0

* *LOK 1 treatments with spray lance held in front of the operator- same row*
LOK 2 treatments with spray lance held downwind in adjacent row.

Figure 1. Operator contamination in cotton on different parts of the body - mg a.i /ha. (assumes an applied dose rate of 300g a.i. per hectare))

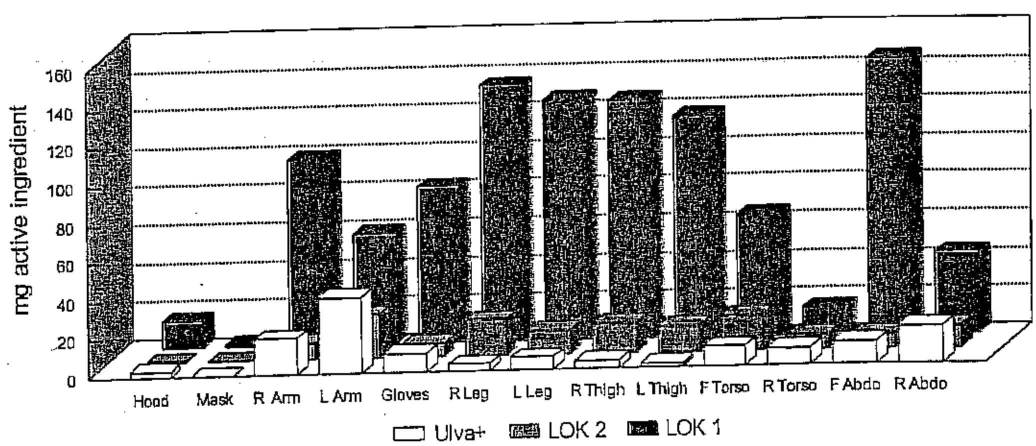

Table 2 Operator contamination in blackcurrants on different parts of the body (µl/litre applied - mean of 12 replicates).

Sprayer Type	Hood (1200)	Mask (172)	R Arm (1350)	L Arm (1350)	Gloves (900)	R Leg (1250)	L Leg (1250)	Rthigh (1900)	L thigh (1900)	F torso (2750)	R torso (2750)	Abdo (7100)
	Body Area (cm²)											
ULVA+												
mean	15.0	1.4	47.0	51.3	29.5	20.1	27.9	18.6	16.1	36.1	24.0	57.9
Std Dev.	31.4	3.3	74.7	93.9	47.0	21.4	31.6	24.9	18.4	56.8	36.7	95.1
LOK												
mean	23.3	1.2	101.8	77.5	75.0	172.4	208.3	309.2	175.8	87.2	12.0	270.9
Std Dev.	33.9	1.5	79.1	47.8	46.1	51.0	123.8	488.2	158.2	42.2	8.9	130.1

Contamination with the ULVA+ sprayer in both trials was significantly lower (P > 0.001) using ANOVA analysis than that found with the LOK sprayer when treatments were made holding the spray lance in front of the operator. Where contamination does occur with the ULVA+ sprayer this is found mainly on the upper part of the body, particularly the arms which are closest to the spray emission.

There is considerable variation between replicates (refer to standard deviations in tables 1 and 2) indicating that operator contamination is highly dependent upon wind conditions and operator use. There was little if any contamination on filter masks suggesting the risk from inhalation to be small with both types of sprayer.

DISCUSSION

Operator contamination studies serve as a useful tool to extrapolate data to assess the potential risks to operators from exposure to pesticides. These can be used in conjunction with other techniques such as analysis of body fluids and models of pesticide absorption .

We can, therefore, draw some useful recommendations from these studies. The most important point is to avoid walking through treated foliage. Contact with sprayed foliage is one of the major sources of contamination with the LOK treatments. Operators of knapsack sprayers should always spray to the side or rear (if possible), standing upwind and ideally should treat the adjacent downwind row to ensure they walk through untreated foliage. The ULVA+ sprayer is intended to be used in this manner where the atomiser head is held 1m above the crop in the adjacent downwind row. This accounts for the considerably lower levels of contamination found with this technique in comparison to the LOK sprayers with lance held in front of the operator. Paying due regard to the wind direction and walking in an unsprayed row should greatly reduce contamination with knapsack sprayers. Another solution to this problem, proposed a number of years ago, is the use of a tail boom to ensure the operator always walks away from the treated foliage and airborne spray.

VLV techniques using the ULVA+ sprayer have been used in a number of areas due to their ease of use and logistical advantages, but successful introduction requires the co-operation of agrochemical suppliers and local extension officers to train farmers in the correct use of this technique. There still remains the potential for misuse with such techniques particularly where the concept of spray distribution using the prevailing wind is not well understood.

These and other studies highlight the need to protect the skin from exposure to pesticides. A common misconception is often that the greatest hazard is due to inhalation of droplets rather than contact with the skin. Contact with pesticides during mixing and filling and handling the concentrate is also a major source of contamination which needs to be considered (Craig and Mbevi, 1993) and highlights the need for appropriate packaging of pesticide products to facilitate measurement and transfer of small doses of pesticides to sprayers. Frequently operators do not have access to gloves hence using soap and water to wash hands after mixing is often the most practical method to minimise pesticide exposure through skin.

The condition of spray equipment, particularly where spray tanks are carried on the back, is also important to avoid leakage onto the operator. Leaking hose pipes, taps and spray lances are also significant sources of contamination which need to be considered.

On the basis of this and earlier studies (Matthews and Clayphon, 1973) it is worthwhile reiterating a number of simple measures to minimise operator exposure to pesticides:-

- Ensure sprayers are correctly maintained and there are no leaks. Read the product label and wear appropriate protection when handling the concentrate.
- Ensure operators protect all areas of exposed skin during spraying using hard shoes or boots with long trousers, long sleeve shirts and hat. In many cases the use of national dress has proved quite acceptable as work clothing in hot climates (GIFAP, 1989).
- Always stand upwind from the point of spray emission and avoid walking through treated foliage wherever possible.
- Use soap and water to wash after handling concentrates and after spraying and immediately remove work clothing for washing.

CONCLUSIONS

Spray treatments with the ULVA+ spinning disc CDA sprayer at Very Low Volume (VLV) rates of application, of around 10l/ha, gave significantly lower levels of operator contamination than comparable treatments at high volumes with Lever Operated Knapsack (LOK) sprayers with hand lance. The majority of contamination with the LOK sprayers was due to operators walking through treated foliage and occurred mainly on the lower front of the body. If possible, holding the spray lance downwind to treat the adjacent row and avoiding contact with treated foliage can greatly reduce the levels of contamination. This is the standard method practised with the ULVA+ sprayer.

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