A.N.P.P. - B.C.P.C. - SECOND INTERNATIONAL SYMPOSIUM ON
PESTICIDE APPLICATION TECHNIQUES
STRASBOURG - 22nd, 23rd and 24th September 1993

A NEW GENERATION HAND-HELD ULVA SPRAYER

J. S. CLAYTON, T. E. BALS and G. S. POVEY

Micron Sprayers Ltd., Bromyard, Herefordshire, U.K.

SUMMARY:
A new design of rotary atomiser disc allows for efficient liquid atomisation over a wide range of disc speeds and liquid flow rates. A hand-held sprayer incorporating this atomiser disc is already in widespread use in sub-Saharan Africa for cotton pest control, using both oil based ultra-low volume formulations at 1 to 3 l/ha and traditional water-based insecticide formulations at total volumes of around 10 l/ha. The sprayer has been designed to be robust and easy to maintain specifically to meet the needs of smallholders. Spray deposition trials on cotton, cowpeas and groundnuts suggest the new sprayer will be suitable for protecting a wide range of crops.

Key words: rotary atomiser, smallholders, CDA, low volume

UNE NOUVELLE GÉNÉRATION DE PULVÉRISATEUR PORTATIF DE TYPE ULVA

RÉSUMÉ:
Un disque de pulvérisation, d'une toute nouvelle conception, permet d'obtenir une vaste gamme de débits grâce à différentes vitesses de rotation. L'Afrique sub-sahélienne utilise déjà des pulvérisateurs montés avec ce nouveau type de disque pour le contrôle des insectes ravageurs des cotonniers. Ces appareils permettent à la fois l'application d'insecticides en formulation UBV (ultra bas volume) de 1 à 3 l/ha et egalement en formulation classique EC (émulsion concentrée) à 10 l/ha environ. Ce pulvérisateur répond parfaitement aux exigences des petits agriculteurs qui en ont apprécié la robustesse et la facilité d'entretien. En plus du coton, les essais de pulvérisation réalisés sur le niébé et l'arachide démontrent que ce pulvérisateur est idéal pour la protection de nombreuses cultures.

Mots-cles: pulvérisation, petits agriculteurs, CDA, bas volume.

Introduction

Spinning disc rotary atomisers provide a well known practical means of achieving narrow droplet spectra (Bals, 1978). Studies have shown liquid atomisation changes with increasing flow rate from direct droplet formation to ligament formation and finally film, or sheet, formation (the last producing an uncontrolled break-up of liquid into a wide range of droplet sizes, much like a hydraulic pressure nozzle). Transition between these mechanisms of liquid atomisation has been studied and empirical atomisation models produced (e.g. Hewitt, 1993) but it has not been possible to derive any universal formula to predict performance, which would appear to be fundamentally determined by the design of the spinning disc.

Development of hand-held spinning disc sprayers

Early discs and cups with plane surfaces and rims produced narrow droplet spectra only at very low liquid flow rates or under narrow equilibrium conditions. Major design advances to allow practical agricultural use of spinning discs were made by Edward Bals who designed cup-shaped discs with a serrated periphery (with these teeth acting as 'zero issuing points') and then grooves on the disc surface to feed each tooth evenly (Bals, 1969; Bals, 1975).

The earliest widespread commercial use of spinning disc sprayers for crop protection was for hand-held application by smallholders, particularly in the arid and semi-arid tropics where scarcity of water meant traditional high volume spraying techniques were inappropriate. ULVA and HERBI types of sprayer were developed for insecticide/fungicide and herbicide application respectively. ULVA type sprayers were developed to apply specific involatile oil formulations at ultra-low volumes (ULV) of 1 to 3 l/ha using small droplet sizes (35-75 µm for 1 l/ha, 50-100 µm for 2-3 l/ha) dispersed by the forces of wind and gravity. HERBI type sprayers produced larger droplet sizes (200-300µm) which sediment rapidly to minimise any risk of spray drift in a placement technique, using either specific oil based, or traditional water based, formulations at total application volumes of 10 to 30 l/ha. Using a narrow range of droplet sizes around the optimum size for the target is referred to as Controlled Droplet Application (CDA).

ULVA type sprayers have been widely adopted in various countries in sub-Saharan Africa (Cauquil, 1987) but their use was restricted to specific ULV formulations which were generally only available for cotton (and migrant) pest control. Research with spinning disc sprayers showed acceptable pest control using traditional water-based insecticide and fungicide formulations (ECs and WPs) applied at very low volumes (VLV) of 10 to 15 l/ha using slightly larger spray droplet sizes of

75-150 µm to avoid problems of evaporation during transport to the crop (Quinn *et al*, 1976; Picken *et al*, 1981). However, problems of high battery consumption and poor motor reliability were experienced with existing sprayers at the higher liquid flow rates required for water-based VLV - meaning that the technique was never widely adopted. Moreover, uniformity of droplet spectra deteriorated at these higher flowrates.

Design of a novel spinning disc

A new rotary atomiser disc for hand-held sprayers has now been developed, capable of maintaining good control of the droplet spectrum over a wide range of disc speeds and liquid flow rates (see Table I). The new disc is of frusto-conical form with a grooved surface and teeth at the periphery. The novel disc design results in very even transfer of spray liquid into and along the grooves and, subsequently, from the grooves onto the teeth. The tooth form has been designed to promote ligament atomisation and produces very narrow droplet spectra when set either for ULV or VLV application (see Figure 1).

Table I: Summary of droplet spectra produced by the new atomiser disc *
Resume du spectre des gouttelettes produites par le nouveau disque

Disc speed (rpm)	Flow rate (ml/min)	VMD	NMD	VMD/NMD ratio	Span: $\frac{(d_{v\,0.9} - d_{v\,0.1})}{d_{v\,0.5}}$
20,000	200	52	44	1.18	0.84
	100	41	38	1.08	0.57
	50	40	37	1.08	0.41
10,000	200	77	57	1.35	1.31
	100	66	55	1.21	0.98
	50	52	52	1.08	0.55
5,000	200	136	91	1.49	0.88
	100	122	117	1.04	0.46
	50	99	92	1.08	0.67

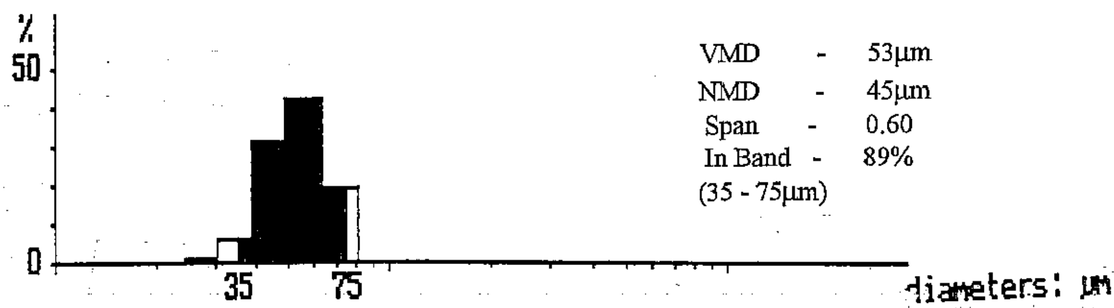
* All measurements made with Malvern Series 2200 laser analyser using water + 0.1% surfactant. Droplet analysis made with 'Dropdata' programme by R. Bateman (IIBC, Silwood Park, London.)

Development of a new hand-held sprayer

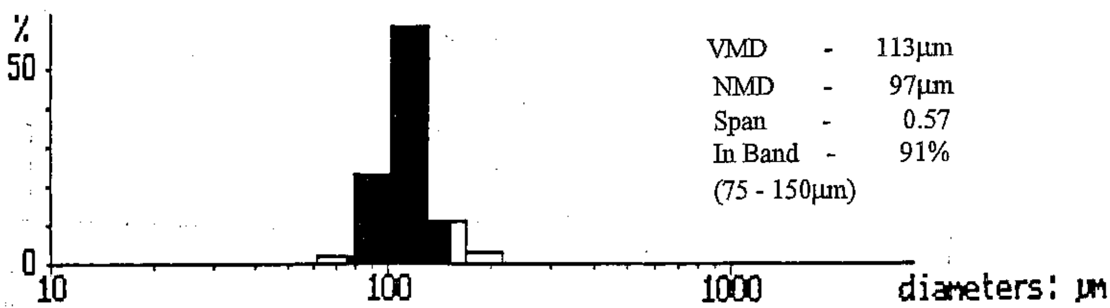
This novel atomiser disc has now been incorporated into a new hand-held sprayer for insecticide and fungicide application, the ULVA+, as described by Clayton (1992). The sprayer is being used for cotton pest control in sub-Saharan francophone Africa, both for oil-based ULV and water-based VLV treatments. Results show spray coverage and biological results with water-based treatments at total application volumes of 10 l/ha at least equivalent to ULV applications, with evidence of improved control of sucking insects e.g. aphids and whitefly (Oudinot, 1989). Introduction of VLV allows greater flexibility with respect to product combinations and dosage rates (as well as application of most biological control agents), which was generally not possible with pre-mixed ULV formulations.

Figure 1. Droplet spectra with the Ulva+ atomiser disc (Malvern series 2200)
Spectre des gouttelettes avec le disque de pulverisation de l'Ulva+

Test Conditions for 1 l/ha: 58ml/min 9,800 RPM. Blank ULV Formulation



Test Conditions for 10 l/ha: 150ml/min, 5300 RPM. Water + 10% emsf. oil.



VLV treatments at 10l/ha are almost as rapid and easy as ULV spraying, thus allowing timely treatment, when compared to high volume manual spraying techniques using knapsack sprayers (see Table II).

Droplet size is varied by changing the number of batteries and hence disc speed. The new disc design allows vastly reduced power consumption for VLV treatments compared with earlier ULVA sprayers (around 1.5-2.0 watts as opposed to 5-8 watts) and consequently 3 to 4 fold improvements in battery life have been achieved (typically one set of local batteries is now sufficient to treat 10 ha). The sprayer has been designed to be robust and easy to maintain, with all field adjustments made by hand and only one screwdriver required for maintenance. VLV has already become well established in sub-Saharan francophone African, being used on around 300,000 ha of smallholder cotton in the 1993 season.

Table II: Time (hrs/ha) taken to spray cotton with alternative application techniques
Comparison du temps (heures/ha) de traitement des cotonniers avec différents pulvérisateurs.

	Application technique		
	High volume	ULV	VLV
Application volume (l/ha)	200	1	10
No Rows treated / pass	1	5	3
	Time hrs/ha		
Collection of water/mixing *	8.50	0.11	0.25
Spraying time	2.80	0.56	0.93
Total time (hrs/ha)	11.30	0.67	1.18

* assumes water source is 1 km from the field. (After Matthews, 1989)

Spray deposition trials with the Ulva+

Trials to examine spray deposition with the ULVA+ on mature cotton, cowpea and groundnuts were undertaken in Chad during 1992. Comparisons were made between application volumes of 1, 3 and 10 l/ha using fluorescent tracers to analyse spray coverage on natural leaf surfaces and magnesium oxide (MgO) slides. Spray treatments were made simultaneously on the same crop with 3 different coloured tracers to minimise variability in application conditions. Table III illustrates the operating parameters for the spray trials. Treatments were made in the early morning (except those on groundnuts) with temperatures between 28 and 32° C. Plot sizes were around 0.15 ha.

Table III Operating conditions during treatments.
Conditions opératoires pendant les traitements.

App^{n} volume (l/ha)	No. of rows (band in m)	No. of batteries	Disc speed (rpm)	Liquid flowrate (ml/min)	Formulation	Tracer
1	6 (4.8m)	8	10,000	35	Oil (ULV)	Saturn Yellow
3	4 (3.2m)	6	7,200	60	Oil (ULV)	Comet Blue
10	3 (2.4m)	5	5,800	150	Water (VLV)	Neon Red

Droplet counts were made on leaf surfaces and slides at three levels (top, middle and bottom) in cotton and two levels (top and bottom) in groundnuts and cowpea. Both abaxial and adaxial leaf surfaces were examined. Magnesium oxide (MgO) slides were placed within the crop to examine droplet size distribution and also estimate the quantity of active material deposited per unit area. Table IV summarises the results from leaf counts and MgO slides.

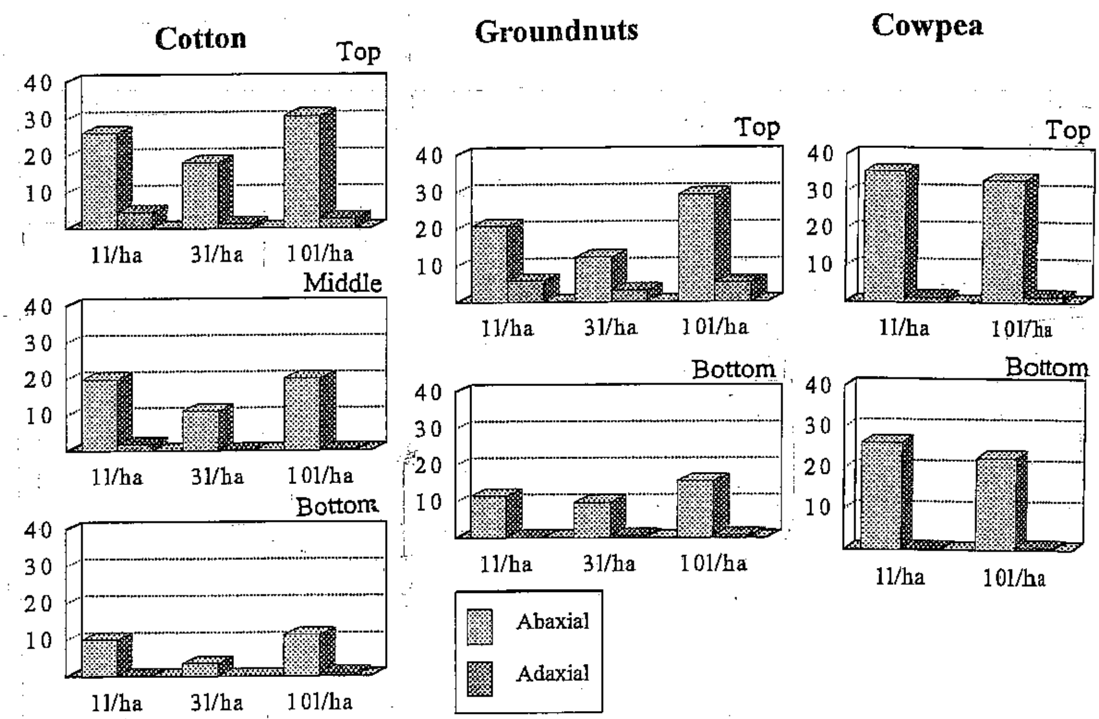
Table IV - Summary of results
Résumé des résultats.

Crop details	Appⁿ vol. (l/ha)	Average wind velocity (m/sec) and conditions	Leaf counts (mean drops/cm²) abaxial	adaxial	Droplet size analysis (MgO) VMD	NMD	Span	Estimated deposit (ng/cm²)*
Cotton (1.7m)	1.1 (1)	0.64 (marginal)	10.0	0.72	-	-	-	-
	2.9 (3)		9.1	0.34	-	-	-	-
	9.7 (10)		15.2	0.60	-	-	-	-
Cotton (1.6m)	1.2 (1)	2.60 (good)	17.3	2.50	49	42	1.21	30.8
	3.3 (3)		-	-	83	63	1.32	31.0
	11.2 (10)		25.3	2.10	127	106	1.20	47.0
Cotton (1.7m)	1.2 (1)	1.25 (fair)	17.6	0.31	-	-	-	-
	4.0 (3)		-	-	-	-	-	-
	10.7 (10)		21.3	0.48	-	-	-	-
Cotton (1.5m)	1.2 (1)	0.75 (marginal)	29.4	5.40	53	72	1.26	31.0
	10.2 (10)		-	-	117	90	1.30	49.3
Groundnuts (0.4m)	1.1 (1)	1.40 (good)	13.8	2.75	46	38	1.21	20.0
	3.2 (3)		10.5	1.86	86	62	1.39	28.3
	9.7 (10)		18.9	5.50	124	90	1.36	39.6
Groundnuts (0.4m)	1.0 (1)	0.74 (marginal)	18.5	3.30	52	40	1.30	30.8
	2.2 (3)		11.5	1.93	79	65	1.20	17.4
	8.9 (10)		25.7	3.40	100	76	1.30	13.4
Cowpea (0.45m)	1.2 (1)	0.56 (marginal)	35.8	0.36	55	43	1.28	27.3
	9.2 (10)		25.7	0.40	129	88	1.47	42.8
Cowpea (0.45m)	1.3 (1)	1.18 (fair)	26.4	1.34	55	45	1.22	40.4
	9.1 (10)		30.0	1.70	117	90	1.30	48.4

* Data analysis from MgO slides provided by programme obtained from NRI, Chatham, London. Assumes dose rate rate of 36 g a.i./ha of a pyrethroid.

The results indicate similar droplet counts for all volume application rates, although the water-based 10 l/ha treatments in cotton, and to a lesser extent groundnuts, gave marginally higher counts. This is most likely due to more frequent spray passes with narrower swaths at 10 l/ha. Reducing the effective swath does however lower the work rate. Measured droplet sizes are consistent with laboratory data suggesting little evaporation had occurred during transport to the crop. With water-based treatments at 10l/ha this is probably due to the higher sedimentation velocities of the larger droplet sizes (100-120 μm VMD). Estimates of the actual quantity of active ingredient/cm² were variable between treatments although, overall, similar quantities were found in all crop situations. There is a suggestion of higher deposits with the water-based treatments in cotton, however, these results are tentative and based upon a limited sample of MgO slides. Further work using fluorometric techniques would be required to more accurately define the actual quantities of active ingredient being deposited. Analysis of spray coverage throughout the crop in each treatment indicated that good wind conditions (consistently above 1 m/sec when measured at a height of 2m above ground) improved underleaf coverage, at least in the top of the plant, in both cotton and groundnuts. Underleaf cover in cowpea was poorer, presumably due to the density of the leaf foliage. The results in cotton are supported by earlier work by Deguine (1989). ULV spray treatments have been successfully used on both cowpea (Raheja,1976) and groundnuts (Mercer,1976). It is considered that results should be comparable with the 10 l/ha VLV technique, and indeed water based VLV treatments using spinning disc sprayers have already been successfully tested against foliar diseases of groundnuts (Salako,1985).

Figure 2 - Partitioning of spray deposit based on leaf counts (drops/cm²)
Répartition du dépôt de pulvérsation sur les feuilles (gouttelettes/cm²)



Summary

The development of a new spinning disc rotary atomiser and its incorporation into a simple and robust hand-held CDA sprayer for both ULV and VLV application offers great potential for smallholder crop protection. The ease of use, speed and timeliness of application are particularly relevant to successful implementation of smallholder Integrated Pest Management (IPM) programmes.

Acknowledgements:

We are indebted to the research staff of the Institute de Recherche du Cotonnier et Textiles (IRCT), Montpellier,France for collaboration in field trials; in particular Alain Renou at Bebedjia,Tchad and Jean-Pierre Deguine in Maroua, Cameroun .

References:

BALS, E.J. 1978 - The reasons for C.D.A. (Controlled Droplet Application). Proc. Br. Crop. Prot. Conf., 659-666.

BALS, E.J., 1975 - The importance of Controlled Droplet Application (CDA) in pesticide applications. Proc. 8th Br. Ins. and Fung. Conf., 153-160.

BALS, E.J., 1969 - Design of rotary atomisers. Proc. 4th Int. Agric. Aviation Congr., 156-165.

CAUQUIL, J., 1987 - Cotton-pest control: a review of the introduction of ultra-low-volume (ULV) spraying in sub-Saharan French-speaking Africa. Crop Protection, 6(1), 38-42.

CLAYTON, J.S., 1992 - New developments in Controlled Droplet Application (CDA) techniques for small farmers in developing countries - opportunities for formulation and packaging. Proc. Br. Crop Prot. Conf., 333-342.

DEGUINE, J.P., 1989 - Étude du récouvrement des cotonniers par les techniques de pulvérisation à bas volume (BV) et à ultra bas volume (UBV) au moyen de traceurs fluorescents. Actes Conf. de la recherche cotonniere africaine, 249-260.

HEWITT, A.J., 1993 - Droplet size spectra produced by air-assisted atomizers. J. Aerosol Sci., 24(2), 155-162.

MATTHEWS, G.A. (1989) - Changes in application techniques used by the small scale cotton farmer in Africa. 1st African Cotton Conf. Lome, Togo.

MERCER, P.C., 1976 - Ultra-low volume spraying of fungicides for the control of Cercospora leafspot of groundnuts in Malawi. PANS 22(1). 57-60.

OUDINOT, O., 1989 - Experimentations sur la technique bas-volume à l'eau en culture cotonniere au Cameroun. Actes Conf. de la recherche cotonniere africaine. 271-282.

PICKEN, S.R.; HEINRICHS, E.A.; and MATTHEWS, G.A., 1981 - Assessments of water based controlled droplet application of insecticides on lowland rice. Tropical Pest Management, 27(2), 257-261.

QUINN, J.G.; JOHNSTONE, D.R.; and HUNTINGDON, K.A., 1975 - Research and Development of High and Ultra-low Volume Sprays to Control Tomato Leaf Diseases at Samaru, Nigeria. PANS, 21(4), 388-395.

RAHEJA, A.K., 1976 - ULV Spraying for Cowpea in Northern Nigeria. PANS, 22(3), 327-332.

SALAKO, E.A., 1985 - Fungicidal control of groundnut leafspots and rust by ultra-low volume spray. Tropical Pest Management, 31(1), 63-66.