A NEW GENERATION HAND HELD SPINNING DISC SPRAYER THE MICRON ULVA+ FOR SMALL FARMER CROP PROTECTION

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Introduction

Recent trends in cotton pest control in Francophone Africa and elsewhere have required the development of a completely new generation of hand held spinning disc sprayer. Crop protection programmes which previously relied exclusively upon ULV (Ultra Low Volume) application at 1-3 l/ha are being modified to also utilise water based very low volume (VLV) spraying at rates of around 10 l/ha. This places new demands upon spray equipment and has necessitated the development of new atomiser technology and improved sprayer design.

Historical Development of Hand Held Spinning Disc Sprayers

Hand held spinning disc sprayers were first introduced into East Africa for control of cotton pests and diseases almost 25 years ago to apply oil based formulations at volume rates of around 3 l/ha. Micron Sprayers pioneered the development of ULV spraying and, following work in the late 1950s and early 1960s with rotary atomisers for locust control, produced the first commercially available spinning disc hand sprayer, the Ulva 16, for small cotton farmers in Africa. The ULV technique demanded finely atomised droplets of a relatively even size which could be dispersed over the target crop by the wind. Oil based formulations were essential to minimise the effects of evaporation on such small droplets. The use of spinning disc sprayers powered by torch batteries provided a very simple and effective means by which farmers could treat their crops. Traditional methods of spraying using knapsack sprayers to apply volume rates of between 300 - 1,000 l/ha of water-based sprays had proved extremely laborious and impractical in many areas of small farmer crop production in Africa.
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The scarcity of water and the effort involved in fetching and transporting large quantities to the fields meant that farmers were unable to apply chemicals effectively - if at all. As a consequence, due to the wide variety of insect pests which attack cotton, farmers were not able to benefit from the use of agrochemicals and hence yields invariably remained low. The introduction of ULV spraying provided a very rapid means of applying pesticides quickly and effectively and revolutionised cotton crop protection in many developing countries.

By the mid 1970s the Ulva 8 sprayer was introduced with a telescopic handle for ease of transportation and storage. Due to the growing acceptance of ULV spraying a number of other manufacturers also began to produce similar equipment. By the early 1980s further improvements in atomiser design by Micron increased battery life considerably with the development of the Micro-Ulva. By the mid 1980s ULV spraying had become the standard technique for cotton crop protection in Francophone Africa where 97% of all cotton was protected in this way, (Cauquil, 1987). During this period ULV formulations became much more widely available from a number of suppliers which progressively reduced the costs of formulations. Further savings in chemical expenditure were possible with the introduction of the Micro-Ulva where by using smaller droplet sizes of around 50-60μm VMD (Volume Median Diameter) to maintain droplet coverage on the plant foliage, it was possible to reduce volume rates down to 1 l/ha. This also led to increased workrates as up to 6 rows of cotton could be treated from a single pass as opposed to 4 rows with 3 l/ha applications.

Also in the mid 1980s the Electrodyn system was developed by ICI using oil based chemicals at application rates of between 0.5 - 1 l/ha. This technique also has very low battery consumption and by using electrostatically charged small droplets avoids the need to rely upon the wind for droplet dipersal and impaction. The technique does however require specialised formulations which are available from only one supplier. The ED technique, as with other application techniques has its advantages and limitations e.g. workrates are generally much lower than ULV techniques with hand held spinning disc sprayers.

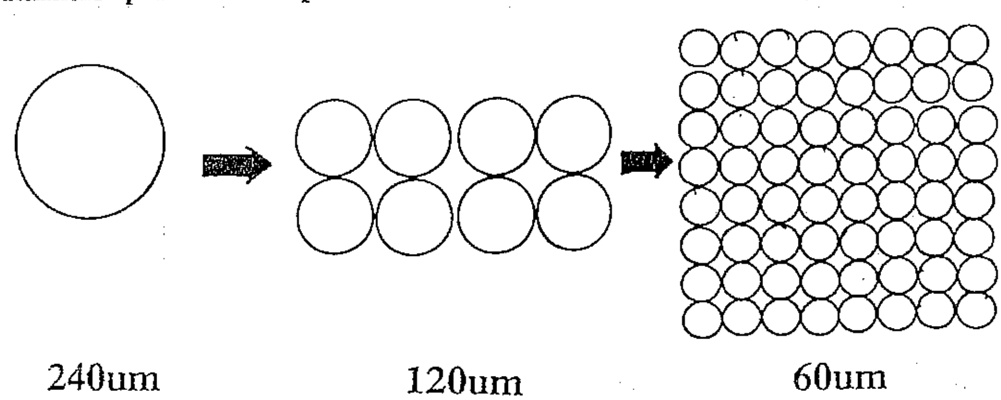
In recent years, however, there has been increasing interest in Francophone

Africa in using water based sprays applied at very low volume rates, around 10 l/ha, with spinning disc applicators. The reasons for this are varied. Using Emulsifiable Concentrate (EC) formulations it is possible to select active ingredients and dosage rates appropriate to the pest status. Using reduced swaths of 3 rows as opposed to 4 or 6 can improve droplet coverage on the plant foliage (Deguine, 1989) as more time is spent treating the crop and less variation in droplet deposition will occur with reduced swaths. Biological results from field trials in the Cameroon, Cote d'Ivoire, Togo and elsewhere have shown favourable results with this technique. Recently, however, the main impetus for change from ULV spraying has been to reduce the costs of treatments. Using 3 litres of an oil based formulation per hectare will invariably be more expensive than using say 1 litre of EC formulation made up to 10 litres with water. There are however a number of implications with regard to spraying techniques when using water based sprays at very low volume rates, the most important of which is the requirement to use the appropriate droplet size to maintain coverage of foliage yet avoid losses through evaporation.

Physics of Spray Application

Using water based spray liquids as opposed to ULV formulations necessitates the use of larger droplet sizes which fall more rapidly and are therefore less prone to evaporation. Larger droplet sizes contain more liquid volume, however, and it is therefore necessary to increase the application rate accordingly to maintain droplet coverage. Overlarge droplets are wasteful as they are poorly retained upon plant foliage and will sediment rapidly giving poor coverage of the swath. Figure 1 illustrates the relationship between droplet size and volume.

Figure 1 Relationship between droplet size and volume



It is therefore essential to use the appropriate droplet size with water based sprays to avoid wastage from overlarge droplets or droplets too small which evaporate and fail to reach the target.

The approximate life and fall times of a water droplet are given by the formulae : -

$$t = \frac{(d)^2}{80\ \delta T} \qquad \text{and} \qquad D = \frac{1.5 \times 10^{-3}\ (d)^4}{80\ \delta T}$$

where, t = lifetime of droplet in seconds
d = droplet diameter μm
T = difference between wet and dry bulb temperature °C
D = distance of fall in still air before extinction (m)
(after Matthews , 1979.)

Using the above formulae it is possible to calculate the theoretical lifetime of different droplet sizes and the distance they will fall before extinction under different conditions of temperature and relative humidity (refer to Table 1).

<u>Table 1</u> **Lifetime and fall distance of water droplets under different ambient conditions.**

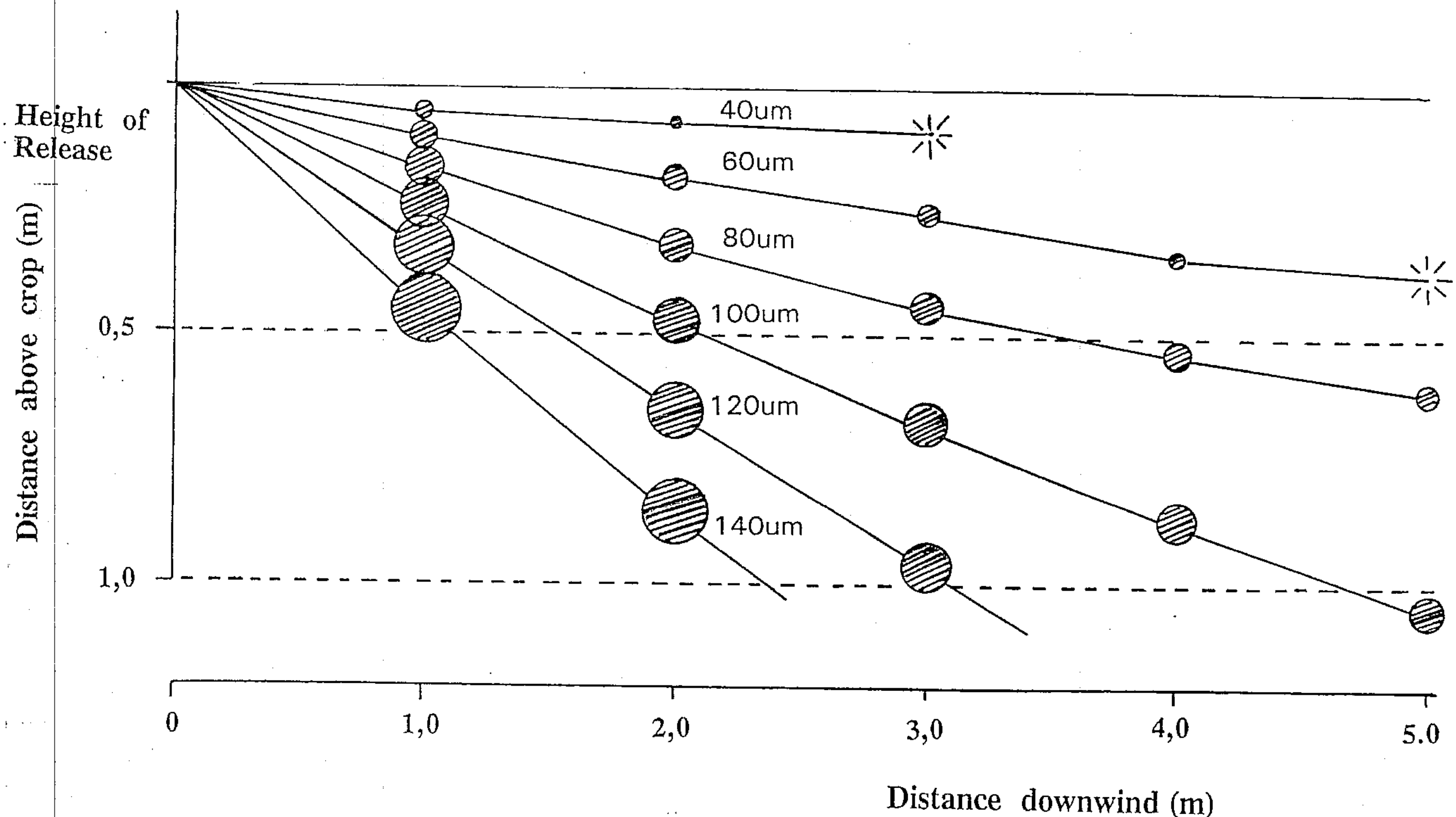
	25 °C RH 75%		30 °C RH 50%		35 °C RH 40%	
Initial droplet diameter(μm)	lifetime (secs)	distance (m)	lifetime (secs)	distance (m)	lifetime (secs)	distance (m)
140	81	24.0	32	9	23	6.9
120	60	13.0	23	5	17	3.7
100	42	6.3	16	2.4	12	1.8
80	27	2.6	10	1.0	7.7	0.7
60	15	0.8	5.8	0.3	4.3	0.23
40	6.7	0.15	2.6	0.06	1.9	0.04

Under conditions of high temperature and low relative humidity e.g. 30 ° C and 50% Rh, as can commonly occur during the time of spraying, the table indicates that droplets under 80μm in size will have evaporated before reaching the crop if released from a height of 1m. Lowering the release height will improve the recovery but reduce the effective swath. However droplets under 60μm are still unlikely to arrive at the crop even from a height of 0.5m. Figure 2 illustrates the trajectories of different droplet sizes in a 1m/sec wind. Clearly these figures are purely theoretical as the involatile constituents of the EC formulation will limit evaporation to some degree. Furthermore turbulent mixing of air occurs with a windflow over a crop which will force droplets down into the crop. Convective air currents and turbulence can also, however, throw the smaller droplets upwards if their fall velocity (sedimentation velocity) is less than the upward air movements. For practical purposes previous research has indicated that where water based sprays are used droplet sizes should be in the range of 100μm - 120μm VMD (Volume Median Diameter) at volume rates of around 10 - 15l/ha (Picken *et al*,1981. Johnstone 1971. Bateman 1989.)

Implications of the 10 l/ha Technique for Sprayer Design

To date spray equipment designed for use with ULV formulations have been modified to apply the higher volume rates of 10 l/ha by simply adding a reservoir tank, usually 5 litre capacity, carried on the back to refill the spray bottle. Initial field trials in the Cameroon during 1987 and 1988 with the 10 l/ha technique were undertaken using the Micro-Ulva sprayer set to produce larger droplet sizes by reducing the number of battery cells. However, it was found that due to the higher flowrates, typically around 150 ml/min, used with the 10 l/ha technique the disc was subject to over-feeding which subsequently gave a deterioration in the quality of the droplet spectrum. The Micro-Ulva sprayer was therefore not considered appropriate for this technique and is only recommended for ULV treatments. Since then large scale implementation of the 10 l/ha technique has proceeded with older generation sprayers, e.g. Ulva 8, which whilst having proved adequate in biological performance suffer from high battery consumption due to their larger disc diameters (8cm and above) and the high flowrate being used. Furthermore with these types of sprayer it is not possible to alter droplet size according to the application technique other than relying upon the higher flowrates to slow down the disc speed to increase droplet size. Moreover,

Fig 2 Theoretical displacement of evaporating water droplets in a 1 m/sec wind.
[Temp. 30^0 C RH 50% ($\delta T = 7.7$)]

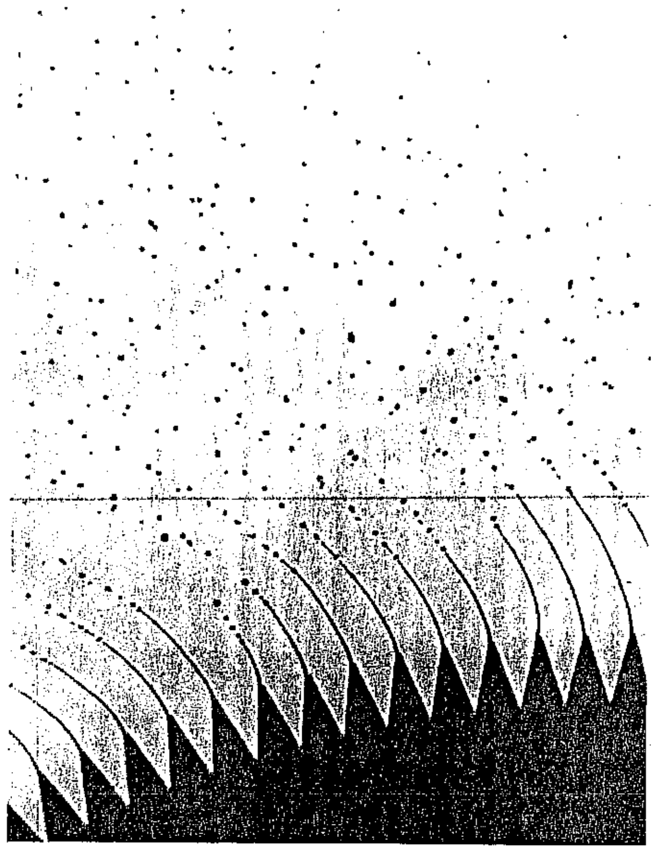


high flowrates greatly reduce the life of the motors in the field. Motor durability is an important feature as more time is spent spraying with the 10 l/ha technique therefore spray equipment is required to last longer than with the traditional ULV techniques. As new spray programmes are required to be much more flexible it is essential that any new hand held sprayer should have the facility to alter droplet size accordingly to suit different application conditions, whether applying ULV or VLV treatments. The requirement was thus to develop a new sprayer which gave greatly improved battery consumption compared with existing equipment and was capable of maintaining good control of the droplet spectrum over a wide range of flowrates and disc speeds.

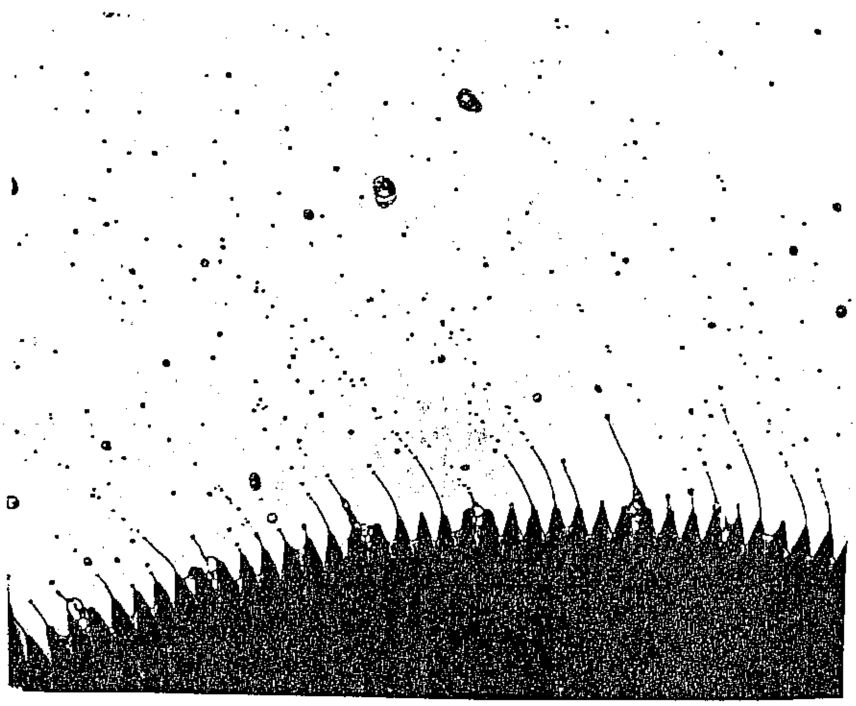
Development of the Ulva+

Initial prototypes of the Ulva+ sprayer were tested during the 1990 season in Cameroon, Togo, Central African Republic and elsewhere. Trials were conducted at application rates of 10 l/ha using droplet sizes of around 100μm VMD. In Cameroon trials were also conducted with the same sprayer applying ULV formulations at 1 l/ha using droplet sizes in the range 50-60μm VMD. Droplet size was selected by changing the number of batteries. The results from a series of extensive field trials indicated biological efficacy comparable to other application techniques and confirmed that the sprayer could be used effectively for both ULV and VLV spray applications. Tests on the battery consumption also indicated the much greater battery economy possible with this sprayer over existing equipment (Sognigbe, 1991). Following this work development has been continued by Micron to further improve atomisation characteristics as well as the robustness and durability of the overall sprayer. A completely new atomiser disc form has been developed to handle a range of flowrates over different disc speeds to ensure good control of the droplet spectrum. This disc form has been developed with the aid of laser based particle sizing equipment and the use of high speed photographic imagery. Figure 3 illustrates the formation of droplets from the edge of the new disc at high flowrates with the Ulva+ in comparison to older disc designs. Figures 4 and 5 illustrate the droplet spectra at different operating parameters of the Ulva+ and the relatively even droplet size. A number of important features are now included in the Ulva+ sprayer and these are detailed in Figure 6.

<u>Fig 3</u> **Formation of droplets at disc edge (x7)**



Formation at high flowrates - new disc form



Formation at high flowrates - old disc form

Fig 4 Ulva+ with a water based formulation.

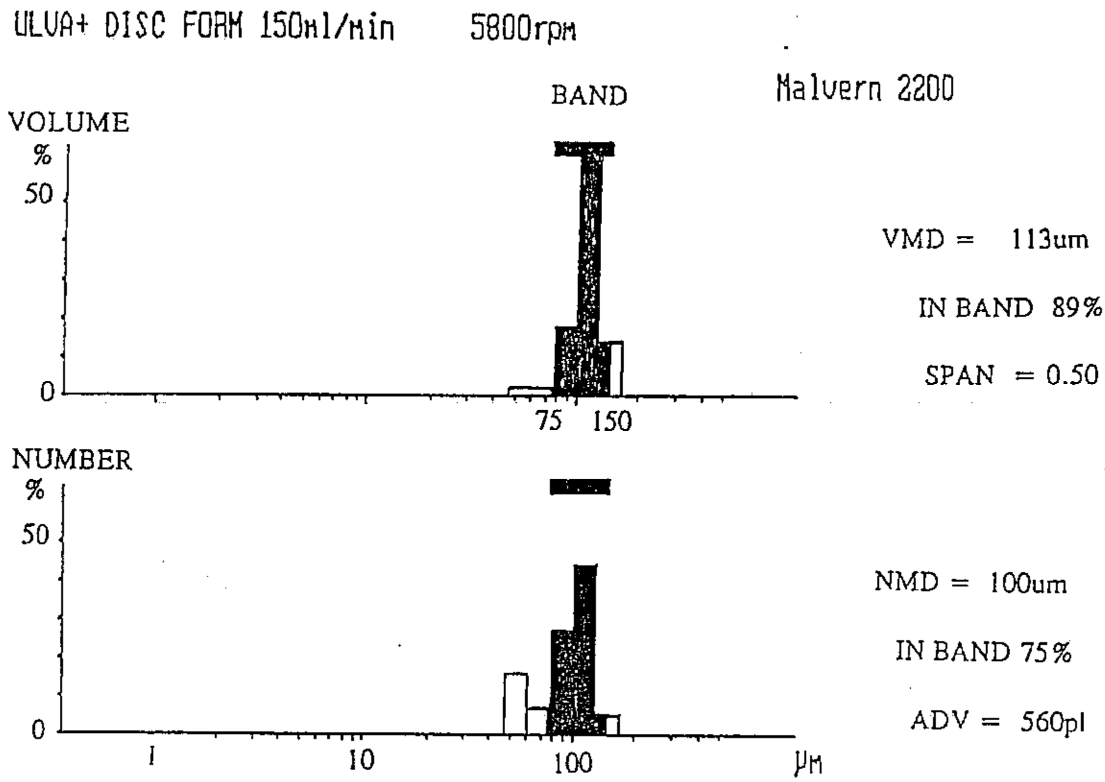


Fig 5 Ulva+ with an oil based formulation.

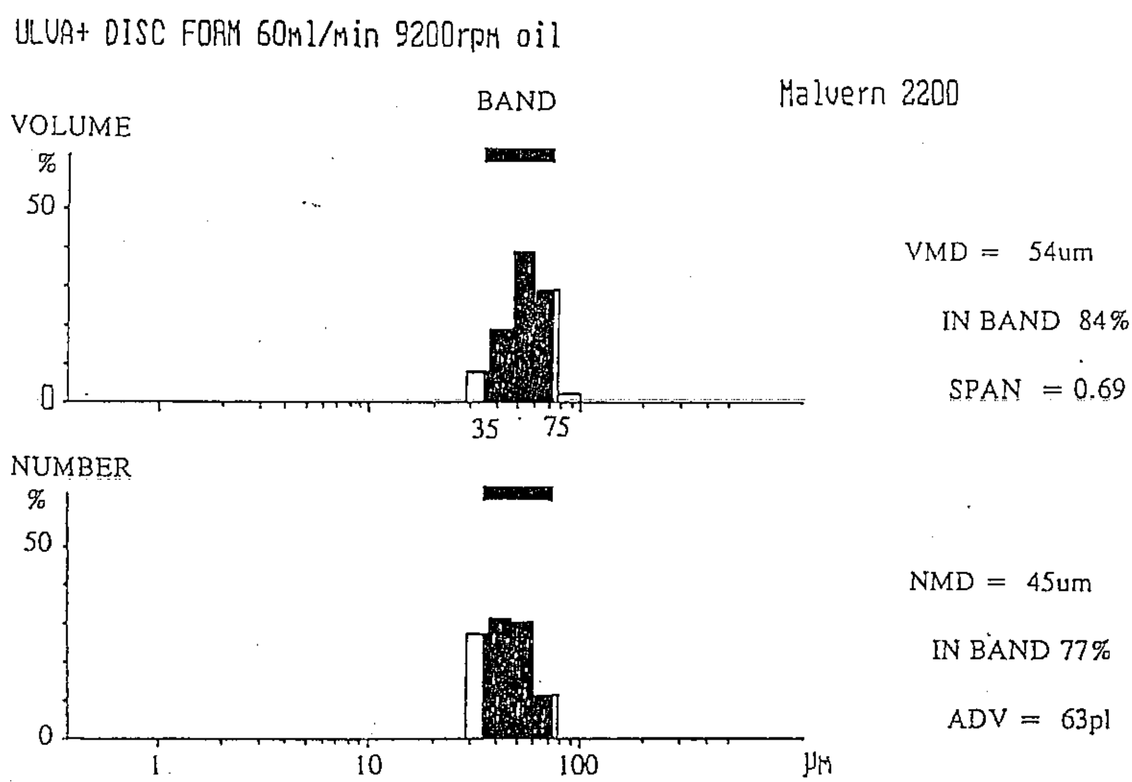
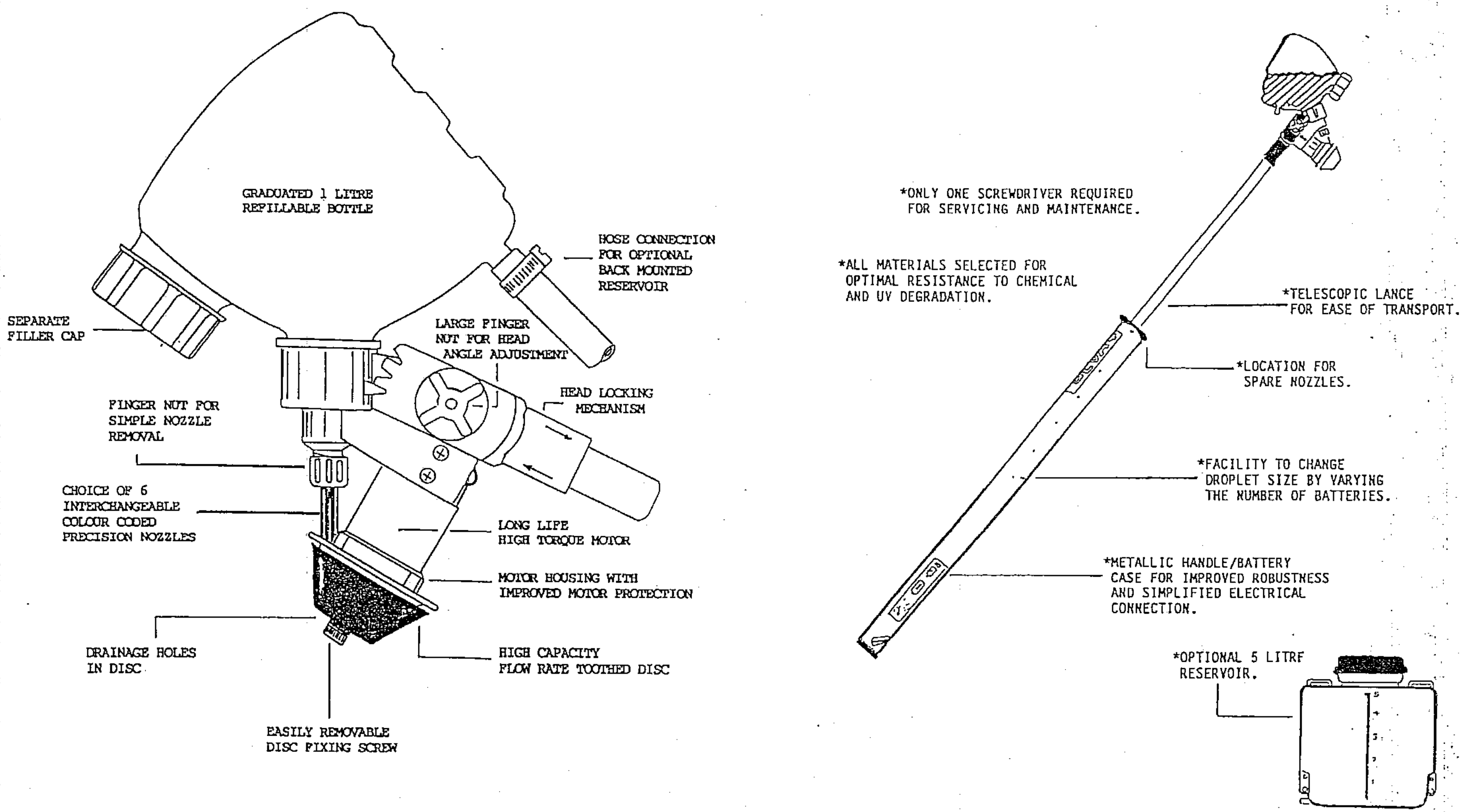


Fig 6 Features of the Ulva+



- atomiser capable of maintaining control of droplet size over a wide range of flowrates and disc speeds with both oil and water based sprays.

- motor durability and protection have been improved.

- very low battery consumption.

- a wider range of nozzles are available which are simply interchanged without the need for seal materials which can swell when exposed to chemicals. Changes in the nozzle material have improved reliability of flowrates and offer greater resistance to deformation of orifice diameters through misuse.

- ability to alter droplet size by changing the number of battery cells.

- drainage holes have been included in the disc to avoid accidental flooding.

- graduated 1 litre refillable bottle with separate filler cap.

- head angle adjustment mechanism which is simple to operate (adjustable by hand) yet rigidly secure.

- metal handle/battery case for improved robustness and simplified electrical connections. This improves reliability in the field and makes servicing and maintenance simple.

- telescopic lance which allows for easier transport of sprayer.

- location on handle for spare nozzles.

- optional 5 litre (or 10 litre) back mounted reservoir with large filler cap and filter basket.

- all plastic, metal and hose tubing materials selected for optimal chemical resistance and UV stability.

- only one screwdriver required for maintenance. Most adjustment on the sprayer is possible without tools.

Figure 7 shows the results from tests on battery life using the Ulva+ sprayer with different numbers of batteries. With good quality batteries it is possible to achieve up to 15-20 hours spraying under all operating parameters. This is in contrast to older generation sprayers which under the same test conditions gave only 5-7 hours spray operation before disc rpms fell appreciably (despite using a larger number of batteries). As disc rpm falls so droplet size increases reducing effective coverage of the crop foliage.

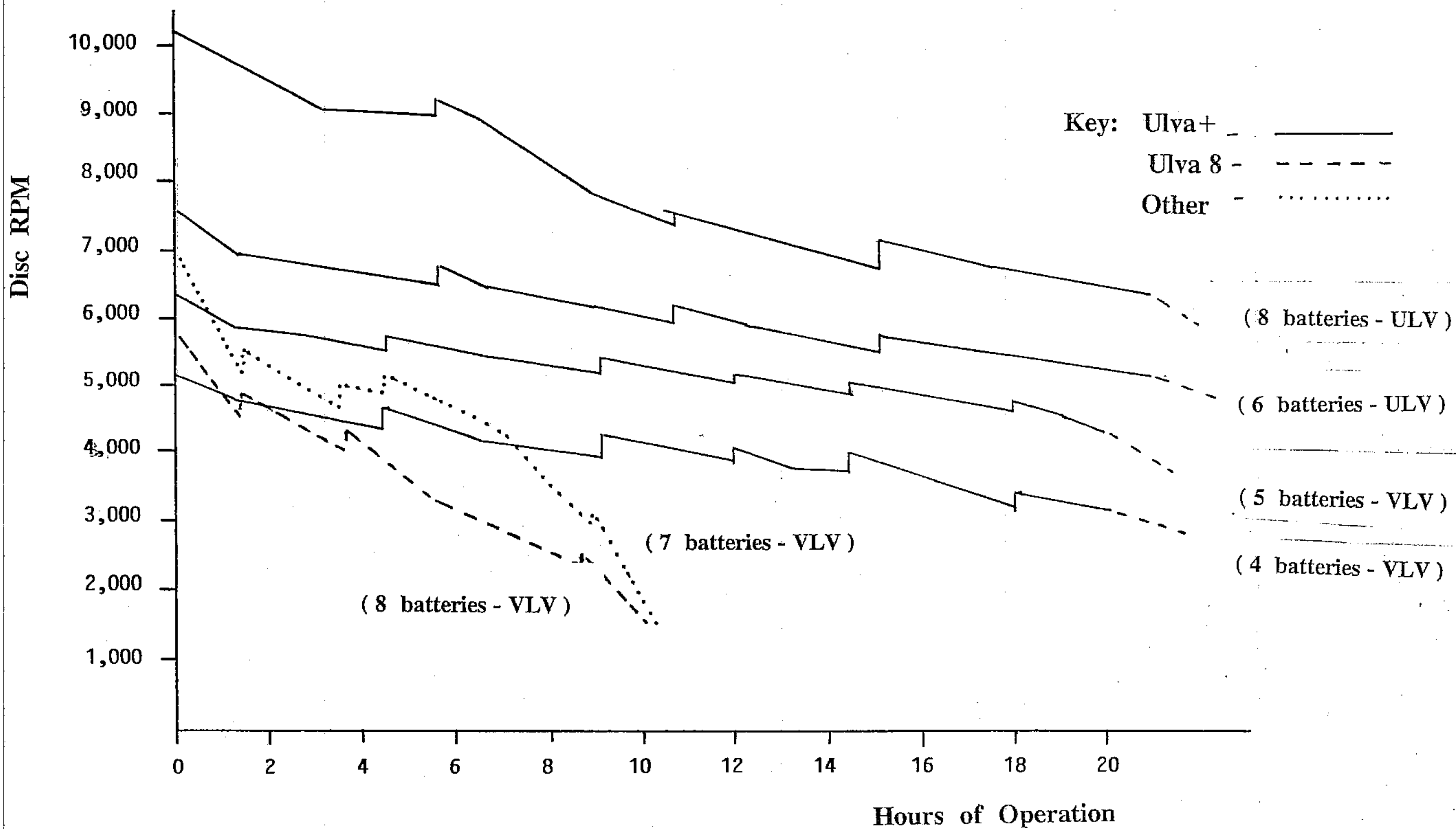
Possible Future Developments In Cotton Crop Protection

Due to the wide variety of insect pests which attack the cotton crop the use of agrochemicals will continue to play an important role in crop protection, although increasingly the emphasis will be upon the more selective use of these products. Techniques using pest scouting and intervention thresholds may be developed in certain situations. How far in practice crop protection programmes can embrace the principles of Integrated Pest Management (IPM) remains to be seen, however opportunities exist with the introduction of the very low volume technique at 10 l/ha to select products and dosages appropriate to the nature and level of pest infestations. It is possible (although less flexible than the VLV technique) to also accomodate more rational spray programmes with the use of ULV formulations by adopting scouting techniques to delay the onset of spray treatments or by varying dosage rates through adjustment of the swath width, e.g. applying lower volume rates during the early part of the season when the crop is less well developed and leaf area is lower (indeed this often occurs in actual spray practice). It is therefore highly appropriate for IPM for farmers and cotton growing organisations alike to have spray equipment capable of accomodating either technique. Also the VLV treatments at 10 l/ha may not be appropriate in certain drier areas.

Fig 7 Comparative tests upon battery consumption.

(Test conditions - Sprayers operated on a cycle of 20 mins on / 10 mins off)

Flowrates : ULV 60 ml/min
VLV 150 ml/min



The use of the 10 l/ha treatment with spinning disc applicators increases the available choice of chemicals as EC, micro-encapsulated and other novel formulations (e.g. certain biologicals) can be applied with this technique. One of the disadvantages is the requirement for farmers to mix products. It is widely recognised that handling the products is one of the main sources of operator contamination. It was always intended with the introduction of ULV spraying that chemicals should be provided in pre-packaged containers ready to screw directly to the sprayer. Unfortunately, largely due to increased costs associated with such packaging this was never fully adopted. The exception to this is the Electrodyn system where pesticide is delivered in the pre-packaged bottle. It is hoped that in the future new developments in formulations and packaging may improve operator safety e.g. the use of micro-encapsulated formulations can reduce toxicity to operators of traditional insecticides such as organophosphates. Packaging improvements such as providing products in containers with appropriate measuring and dispensing facilities would also be an improvement. The use of water soluble sachets, gels or granules (possibly as farmer packs) can also be used with the VLV technique to minimise handling of chemicals and avoid unnecessary mixing and application errors. There is also scope to accomodate spray additives to reduce the effects of evaporation and possibly improve retention on leaf surfaces. This technique is practised in Malawi and Zimbabwe where molasses have been used for this purpose applying volume rates as low as 5 l/ha with water based sprays.

Whether ULV, VLV (10 l/ha) or other spray practices are used will depend upon the preference of individual farmers/cotton growing organisations and it is likely this will be strongly influenced by the costs of treatment. The proportion of costs in purchasing and maintaining spray equipment is in reality very small , around 5% ,(Gaudard,L. 1990) in comparison to the costs of chemicals hence it is this latter factor which will no doubt dictate which application methods are adopted. The time involved in undertaking spray treatments will also be an important determining factor for many smaller farmers.

Table 2 Nominal times (hrs/ha) taken to treat cotton with alternative spray methods

Sprayer method swath (rows)	Knapsack* 1	ULV 5	VLV* 3	ED 2
Collection of water and/or mixing	8.5	0.11	0.25	0.05
Time for spraying in the field	2.8	0.56	0.93	1.4
Total time	11.3	0.67	1.18	1.45

(after Matthews, 1989)

*assumes water source is 1Km from field

Conclusions

The development of the Ulva+ removes the major constraint in using spinning disc sprayers to apply water based sprays at low volume rates by greatly improving battery consumption and motor durability. Furthermore, by ensuring control of droplet size appropriate for the application technique, whether ULV or VLV this enables the same sprayer to be used efficiently for both methods of application. This added flexibility in the choice of application technique and chemicals should benefit all small farmers, not only cotton farmers, as it should now be possible to expand the use of these techniques into other crop situations, perhaps food crops such as rice and maize, where traditionally only formulations appropriate for dilution in water have been available.

The overall aim of Micron Sprayers remains the same as it has been for the last 30 years, namely to bring appropriate and affordable technology to all small farmers in order to enable them to fully benefit from the use of crop protection products. (Bals, 1969, 1970, 1971.)

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