Aspects of Applied Biology 84, 2008
International Advances in Pesticide Application

Motorised mistblowers: their performance and rationale in developing countries

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Summary

Some of the technical and operational aspects of using motorised mistblowers on tropical crops such as cocoa are described. Mistblowers are often used in centrally co-ordinated control campaigns in Ghana, with these sprayers currently used for applying pyrethroid, neonicatinoid and remaining stocks of organophosphorus and carbamate insecticides against cocoa mirids (*Sahlbergella singularis* and *Distantiella theobromae*). Mistblowers are preferred since cocoa trees in West Africa are often extremely tall, and a high work rate enables timely application. Our current research focuses on optimising delivery systems for alternative microbial control agents (MCAs), such as *Beauveria bassiana*, and assessing their efficacy. The influence of droplet size on the dose transfer of both chemicals and MCAs to insect pests is discussed, together with the logistics and economics of mistblower use in comparison with manually operated sprayers. . Clearly, research to update cocoa mirid control techniques is needed, but much could be done to improve the implementation of known techniques: using established protocols and equipment specifications.

Key words: Motorised mistblowers, tropical crops, West Africa, cocoa mirids, MCAs

Introduction

In Ghana, where 45% of the economy and a possible 60% of the population's income is derived from cocoa (in 2004, FAO statistics put this at a little over US$1 billion), it is vital to maintain an effective pest control strategy. An International Round Table Meeting there in October 2007, included cocoa farmers, cooperatives, traders, exporters, processors, chocolate manufacturers, wholesalers, governmental and non-governmental organizations, financial institutions as well as donor agencies. Consensus was reached on a number of action points for maintaining sustainable cocoa economies: and will be called the "Accra Agenda". Pest management issues featured highly in the list of the priorities, with the following key needs (amongst several others) identified:

- Remunerative prices and increased income for cocoa farmers, including consideration of the impact of fiscal policies;
- Development and promotion of Good Agricultural Practices to increase productivity and quality in a manner that respects both the environment and social standards;
- Reduction of losses due to pests and diseases by introduction of integrated pest management;
- Promotion and support of local services providing improved planting materials, fertilizers, pesticides, etc. and provide related training;
- Mechanization of farm operations to reduce costs where possible;
- Increased labour efficiency through better management practices;

- Sustainable commercialization includes the development of efficient supply chains to increase the margin received by farmers, while maintaining cocoa quality and improving traceability in the value chain.

It is believed that about 25-30 % of the national cocoa acreage in Ghana has significant mirid damage, with an annual crop loss of about 100,000 tonnes (Padi, Owusu-Manu, unpublished). Industry sources suggest mirids cause global annual losses of some 250,000 t of cocoa. First mass spraying in Ghana to control mirids took place between 1959 and 1962; it was centrally organised, and provided maintenance of the sprayers (Quartey-Papafio 1961; Clayphon, 1971), but this system was later discontinued. When a survey by the Cocoa Research Institute of Ghana's Farming Systems Unit was conducted in 1991 only 0.7% of cocoa areas had been sprayed, and not all of these cocoa farmers had successfully followed the recommendations in terms of spray timing and frequency. In 2003 the Ghanaian Government reinstated a national coordinated spray-programme against mirids (CODAPEC) with the aim of increasing both production and employment within the industry. Cocoa was the first of the tropical tree crops to use mistblowers for pest control. This method of application evolved from having a two man team in the 1950s, one with a compression sprayer and the other with a motorised fan to project the spray high into the cocoa trees (Matthews, 1999). In West Africa the crop typically is typically allowed to grow very tall by world standards, and it continues to be not unusual to find trees up to 14 m in height.

Good Agricultural Practices (GAP) that incorporate rational use of insecticides remains one of the sounder strategies for mirid control and a means of minimising residues in produce. In response to this need, there have been a number of research lines that include better understanding of crop-pest interactions and the use of biology-based control agents as possible chemical substitutes that are cost-effective and safe to farmers, consumers and the environment.

Pesticide application techniques on cocoa are essentially based on experiments that were carried out in the 1960s when HCH (lindane) was the AI of choice. HCH has properties (persistence, fumigant action) that are very different from modern pyrethroid and neonicatinoid insecticides (Martin & Worthing, 1977; Tomlin, 2007), let alone slower-acting chemical and biological agents. These should have a low impact on non-target organisms and thus are compatible with Integrated Pest Management (IPM) practices that are at once cost-effective and safe to both farmers and consumers.

There is therefore a need to modify screening methods and laboratory-to-field procedures for assessing these novel control agents. A new Cocoa Research UK funded programme aims to develop improved mirid control techniques, based on better understanding of crop-pest interactions that has accrued over the last three decades. This includes work funded by Department for International Development that led to identification of the sex pheromone for the mirids and to demonstration of the feasibility of developing a mycoinsecticide based on technology developed by the international LUBILOSA Programme (Lomer *et al*., 2001). The immediate objectives of the authors programme are to:

(1) develop better screening methods and laboratory-to-field procedures for assessing more slow-acting chemical and biological agents,

(2) characterise current pesticide application practices, with a view to …

(3) carrying out field trials with candidate mycoinsecticide formulations.

Materials, Methods and Results

Our work to date has focused on two principal aspects of motorised mistblower use:

1. Droplet size spectra and evaluation of motorised mistblowers

The most common design of nozzle is of the air-shear type, in which thin layers of liquid are introduced into the air stream and thus produce fine sprays. The combination of air assistance and production of relatively small droplets, enable motorised mistblowers to achieve good coverage at low volume application rates (i.e. without "spraying to run-off"). They are typically used to apply water based mixtures to trees at very-low volume (VLV) rates (50–200 L ha^{-1}), but low flow rate ULV adapters are available, especially with machines that use a formulation pump. Fig. 1 shows recently obtained droplet size spectra for motorised mistblowers that are commonly used for cocoa and might be used for our field trials. Data for available flow settings were obtained using a 'Spraytec' particle size analyser fitted with a 450 mm lens (Malvern Instruments Ltd., Spring Lane South, Malvern, Worcestershire, UK), but otherwise using procedures described by Bateman & Alves (2000).

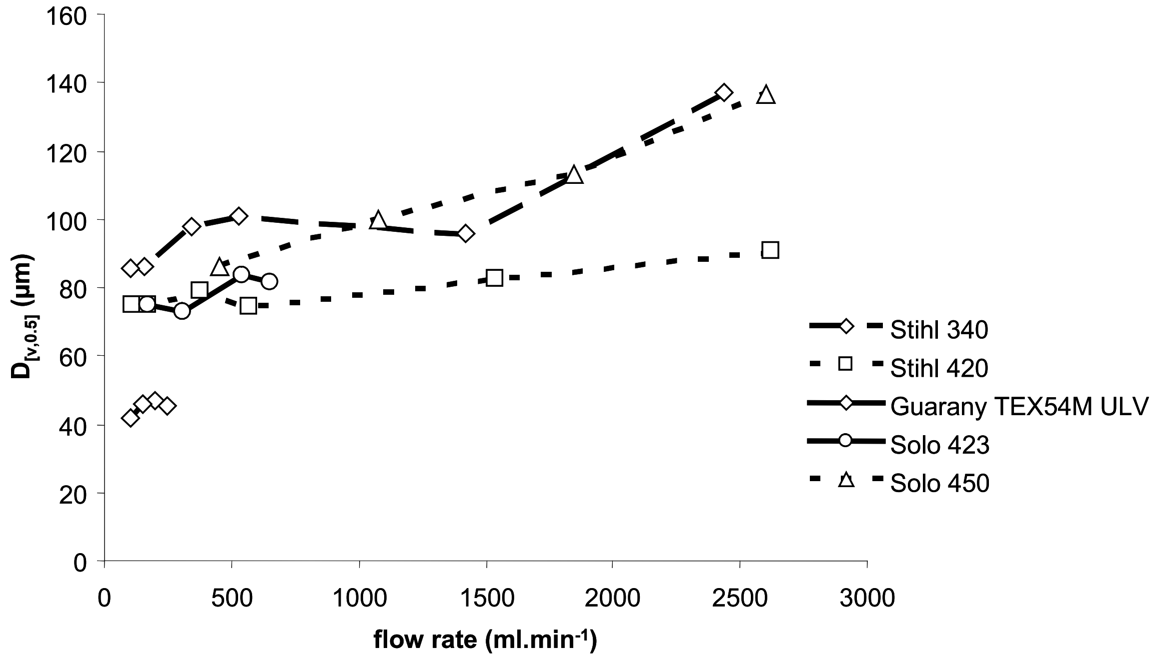

Fig 1. Droplet sizes - D[v,0.5] (VMD) - for five motorised mistblowers.

2. *Assessing application parameters in spraying operations*

Amongst cocoa producers there is often a debate as the most appropriate and cost-effective spraying equipment for use in tree crops such as cocoa. On the one hand, the inability of smallholder farmers to afford the capital costs of mistblowers has been documented frequently; on the other, manual sprayers are evidently incapable of treating the tops of high trees, and have substantially lower work rates and are thus less suitable for large-scale control operations (see below). We have been trying to quantify where the "break even" point may occur for use of motorised mistblowers and illustrate the way data have been gathered in Table 1, using best available current costs in Ghana.

Discussion

Bateman & Alves (2000) carried out a number of spray measurements and discussed the droplet size distributions for mistblowers, and Bateman (1993) suggested that it is helpful to present data as an optimum size range, depending on the formulation used. If droplets are too small, then the risk of losses due to drift increases and they may lack the necessary momentum to reach the desired height or impact on foliage. If the droplets are too large then a large proportion will settle

Table 1. *Illustration of an economic analysis comparing the use of motorised mistblowers, with manual side -lever knapsack sprayers. Financial units are Ghanaian new Cedi (approximately equivalent to the US$; £1 = 1.9 Cedi; €1 = 1.3 Cedi). Manual sprayer parameters are based on the CP15 with a yellow cone nozzle and a low pressure setting and the mistblower spraying is represented by a Stihl SR420 fitted with a #1.6 restrictor and a formulation pump. The tree spacing is 2.5 m × 2.5 m (1600 trees ha^{-1}) and in this illustration we assume that one machine is operated over 10 ha. The time typically taken for mixing/ reloading is assumed to be 20 m*

		Manual	**Mistblower**
1. Sprayer costs			
	Initial capital cost (concessionary prices)	60	688
	Area sprayed annually (ha)	90	90
	Life in years	6	6
	Annual cost of ownership	10.00	114.67
10%	Annual repair and maintenance	6.00	68.80
15%	... interest on half capital	4.50	51.6
	Total cost of ownership (annual: 1 sprayer)	20.50	235.07
	Ownership cost per ha	0.47	2.14
2. Operational costs			
	Tank capacity (leave 1 L empty - standard practice)	14	11
1	Tank load treats # trees =	90	270
	Time to empty tank (mi to treat # trees)	24.0	21.0
	Flow rate (measured L min^{-1})	0.85	0.64
VAR	**(L ha^{-1}): tank loads (rounded) × tank volume**	**252**	**66**
	ha h^{-1} spraying (but not reloading)	0.14	0.48
Fuel	unit cost (1 L)	0.00	0.50
(+oil)	Fuel usage h^{-1} (L ha^{-1})	0.00	1.70
	Fuel cost ha^{-1}	0.00	0.60
	Efficiency of spraying*	**69%**	**82%**
	Tank loads ha^{-1}	18	6
	Application time ha^{-1} (h)	7.1	2.1
	Mixing / reloading time ha^{-1}(h)	6.0	2.0
	ha h^{-1}: total spraying operation	0.08	0.25
	ha treated per working day	0.2	0.5
3. Total cost estimates			
	Cedi day^{-1}; daily effective working hours (see text) =	2	2
	Labour cost ha^{-1} spraying operation	13.11	4.07
	Total operating costs ha^{-1}	**13.58**	**7.97**
	Pesticide costs (per ha season^{-1})	54.00	54.00
	Total cost of spray operation ha^{-1} season (sprayer)	**176.22**	**125.77**
4. Implications for Self contained farms, Co-operatives and Contractors:			
	Reasonable annual use (h)	300	300
	No. of sprayers required	3	1
	Total season operating costs for operational area	**1283.71**	**952.79**
	Total cost of spray operations ha^{-1} (area)	**182.37**	**149.28**
	% application and labour of total cost	70%	64%

*Time actually spent spraying when in the treatment zone.

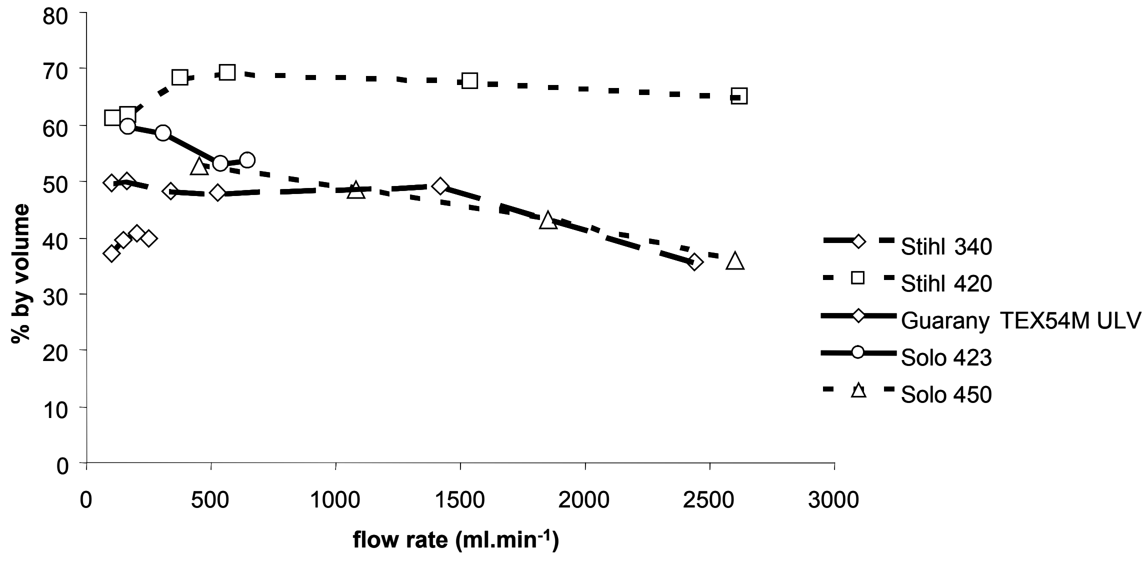

Fig 2. Droplet size spectra of mistblowers used on cocoa: % of spray volume in the range 55-126 µm.

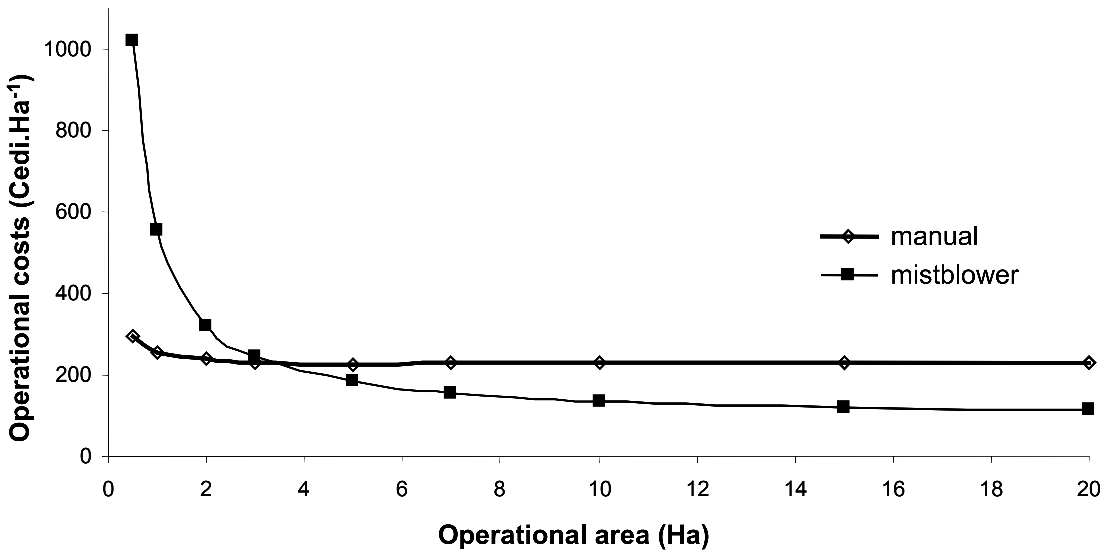

Fig 3. Economic projections for two different types of spraying (based on Table 1).

out onto the ground, or worse, the operator. Therefore, the ideal sprayer will produce a narrow spectrum of droplet sizes within a desired size range. In Fig. 2 we present the same readings as in Fig. 1 as the percentage of spray volume in the range 55–126 µm. We have selected the Stihl 420 (Andreas Stihl AG & Co., Waiblingen, Germany) for future trial work since it appears to maximise in the desired band over a wide range of flow rates. It is robust and conforms to international safety standards, but unfortunately this comes at a cost, with the formulation pump and low volume restrictors alone now retailing at >£100 and (perhaps consequently) often difficult to obtain in developing countries. This is a pity because these parts considerably improve the technical performance of machines.

How much do high capital costs matter? For a smallholder high capital costs are a critical constraint, but work rate becomes increasingly important: the larger the spray operation, the higher the labour costs and the more critical the spray timing. Entwistle (1972) comments on the timing and frequency of mirid sprays. In practice, most mirid spraying occurs during a 2 hour "window" between approximately 8:00–10:00 am - before which operators need to reach the target sites and after which the insects migrate up trees and into crevices, so they are not exposed to sprays. A high work rate is therefore crucial for CODAPEC operations and motorised mistblowers are used as standard, for the average of two annual insecticide sprays provided to cocoa farmers. Typical cocoa farms in W. Africa rarely exceed 2 ha, and only in some parts of Latin America are they likely to be >10 ha. However, demographic and economic factors may change the economic outlook for cocoa growing in the medium-term future. With more intensive growing on larger scales, labour costs become an increasingly important component (e.g. relative to pesticide costs) and obtaining detailed information can be helpful for advising on best practice. We are continuing to obtain data from various cocoa growing areas, and as shown in Fig 3, it can be informative to model the relative costs of spray operations over different operational areas.

Acknowledgements

The authors would like to extend their thanks to Cocoa Research UK for sponsoring this work, together with assistance from Dr. Joe Ackonor, Dr. Tony Cudjoe, Dr. Rob Lockwood, Prof. Graham Matthews, Joe Sarfo and Evan Thornhill. Our sponsors support policies and projects that promote international development and have provided funds for this study as part of that objective. However, the opinions expressed are those of the authors alone; commercial products are described in this article solely for the purpose of providing specific guidance and neither the authors nor our sponsors imply recommendation or endorsement of them.

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