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A comparison of hand-operated pesticide sprayers for the control of groundnut pests in India[a]

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Summary

A knapsack sprayer, a motorised knapsack sprayer, a hand-held single spinning-disc ultra low volume (ULV) applicator, a back mounted apparatus with two spinning-disc ULV applicators on a boom, a hand-powered spinning-disc low volume apparatus (the Birky - Ciba- Geigy), and an electrostatic sprayer (the Electrodyn - ICI) were compared for their efficacy for pest control on groundnut crop. Cypermethrin was sprayed for controlling insect pests on a groundnut crop. All sprayers were equally effective in controlling the insect pests. When the sprayers, except the Electrodyn, were used to apply fungicides on groundnut for the control of foliar diseases (leaf spot and rust) there were no significant differences on one of the genotypes, but with the other only the hand pumped knapsack sprayer was effective for control of both leaf spot and rust. The distribution of the spray droplets in the canopy was similar for different sprayers, except for the Electrodyn, the output of which could not be tested. However, in terms of labour and water use efficiency the low volume and ULV applicators were superior to the conventional sprayers.

Introduction

In many parts of the developing world, technological advances are leading to increased production of groundnut. One of the implications is that many low income farmers are reaching the position where they can boost their production by supplying inputs to their crops in the form of fertilizers, which are often essential, and pesticides, which can be necessary when the situation demands. Many of the recommended pesticide application procedures require a farmer to supply as much as 500 L of water ha^{-1}. This requirement puts considerable hardship on farmers who have to fetch clean water from a long distance. Methods to alleviate the problem have been available for some time (Matthews 1979, Fowler and McDonald 1981). These centre upon use of ultra low volume application of pesticides through spinning-disc applicators. Pesticide solution is thrown off the spinning disc by centrifugal force to form a swath of fine spray. Droplets are of a reasonably uniform size. Another development is a device called the Electrodyn that produces a cloud of electrostatically charged insecticide particles that adhere to the surfaces of the plant.

The effectiveness of the traditional methods (hand operated or motorised knapsack sprayers) and the more modern devices (such as the spinning-disc sprayers) were compared for potential use on groundnut.

Materials and methods

Experiments were carried out during the 1986 post-rainy season and the 1987 rainy season on groundnut sown on raised beds at the farm of the International Crops Research Institute for the Semi- Arid Tropics (ICRISAT) Hyderabad, India. Each bed was 1 m wide, with groundnut crop having a spacing of 10 – 15 cm between plants in rows 30 cm apart. The pesticides applicators tested were:

1. A hand-operated 7 kg knapsack sprayer of 15 L capacity.
2. A 6.5 kg motorised knapsack sprayer of 15 L capacity.
3. A hand-held spinning-disc controlled droplet applicator (CDA) of 1 L capacity weighing 1 kg.
4. A twin spinning-disc knapsack sprayer (TSDKS), constructed at ICRISAT and described by Awadhwal and Takenaga (1990)[1].
5. A hand-powered spinning-disc apparatus, the Birky (Ciba-Geigy), made of plastic, holding 5 L of water and weighing 4 kg.
6. An electrostatic sprayer Electrodyn (ICI) holding 0.75 L of pesticide solution (cypermethrin) and weighing about 1.75 kg.

Cypermethrin was applied at a recommended rate (90 mL a.i. ha^{-1}) with different sprayers for the control of insect pests. Chlorothalonil (1 kg a.i. ha^{-1}) and bavistin (0.5 kg a.i. ha^{-1}) were applied for the control of early and late leaf spots (*Cercospora arachidicola*, *Phaeoisariopsis personata*) and rust (*Puccinia arachidis*) with each of the sprayers except the Electrodyn, since no fungicide is yet available for use with it. The trial for insect control was laid in a 5 × 5 Latin square design with five replications, on plots measuring 240 m^2. Insect intensity (population per plant) was determined with traps before application of pesticides and 36 h after application. The trial for control of diseases was in a split plot design with four replications, each plot measuring 225 m^2. The assessment of disease incidence (score in 1 – 9 scale) was carried out at 20 day intervals. Data regarding water consumed, time taken, and labour required for spraying operations were recorded for each plot. Weather did not cause any noticeable hardship during the experiments. Two non-replicated trials were also conducted for spraying on groundnut in fields each measuring about 1 ha to gather data on work rate, time, and labour requirements for using the sprayers.

The numbers of droplets deposited on the top and middle of the canopy and on the ground surface were assessed by placing strips (4 × 2.5 cm) of commercially available (CIBA-GEIGY), water-sensitive paper in appropriate positions. There were four strips at the three levels in each plot, except where the Electrodyn was

Footnote:

[1] The TSDKS consists of a 10 L tank fitted to a tubular knapsack frame. A 1.5 m boom, which is an integral part of the frame, carries two spinning disc assemblies energised by a 6 v rechargeable battery. It sprays behind the operator. The height of the boom can be adjusted by 1 m but is set to deal with low row crops like groundnut and mung bean. The TSDKS weighs 9 kg.

used. Electrodyn is only suitable for non-aqueous formulations and the sampling papers used were not sensitive to these formulations. Number of droplets were counted using a lens to calculate droplet density (number of droplets cm^{-2}).

Results and discussion

The insect population was reduced significantly ($P < 0.05$) in plots treated with cypermethrin, but there were no significant differences ($P < 0.05$) in effectiveness between the applicators (Table 1). No treatment gave satisfactory reduction in leaf miner incidence. Results from the experiment on control of foliar diseases indicate that the two genotypes responded differently to treatments (Table 2). There was a significant ($P < 0.05$) reduction in incidence of rust and leaf spots in ICG(FDRS) 4, and there were no differences in effectiveness between the applicators as well as chemical types. With ICGS 44, rust levels were reduced significantly ($P < 0.05$) only by bavistin but not by chlorothalonil, and there was no difference between the TSDKS and manual knapsack sprayer. The leaf spot incidence was reduced significantly ($P < 0.05$) only when bavistin was applied with the manual knapsack sprayer.

There was no significant ($P < 0.05$) difference in distribution of droplets in the crop canopy (Table 3) for all the applicators (excluding Electrodyn) which were tested. Most droplets were deposited in the top portion of the canopy, about 30% penetrated into the middle canopy, and little over 25% reached the ground. The importance and relevance of these distribution data depends entirely on the species of insect or pathogen that is being considered. In the case of thrips, jassids, and leaf miner, it is appropriate for most of the spray deposit to be concentrated on the upper leaves. However canopy penetration is needed for effective control of rust and leaf spots especially when contact fungicides are used and the foliage has luxuriant growth, which occurs in some genotypes under conditions of high humidity.

The hand-operated knapsack sprayer, and the motorised knapsack sprayer, were poor in labour, time, and water use efficiency (Table 4). The hand-held spinning-disc (CDA) sprayer and the Birky sprayer did not differ in water usage, and were similar to the Electrodyn in terms of time and labour requirements. Results on the requirements of the knapsack (manual) and hand-held CDA sprayers are in agreement with the results reported elsewhere (Attique and Shakeel 1983, CPPTI 1985). The TSDKS required only half the time and energy (man-hr) required for the hand-held CDA and Birky sprayers because it could cover twice the amount of foliage at one pass. The TSDKS required only 15 L of water and 1.5 man-hr ha^{-1} compared with 500 L of water and 28 man-hr ha^{-1} required for the manual knapsack sprayer.

A disadvantage of the spinning-disc apparatus is that the person applying the pesticides is likely to come in contact with the concentrated product when it is emitted from the applicator. However, the TSDKS allows the operator to walk ahead of spray and the groundnut crop rarely exceeds 50 cm in height, we feel that wearing long trousers, rubber boots, gloves, and face

Table 1. Insect population per groundnut plant[A], 36 h after spraying with different sprayers, ICRISAT Center, post-rainy season 1986 and rainy season 1987

	Post-rainy season 1986		Rainy season 1987		
Sprayer type	Leaf miner	Thrips	Leaf miner	Thrips	Jassids
Knapsack (manual)	0.63	2.00	12.4	0.10	0.02
TSDKS[B]	0.25	1.72	14.0	0.24	0.02
Electrodyn	-	-	13.1	0.50	0.04
Birky-	-	14.5	0.20	0.02	
Knapsack-(motorised)	-	12.8	0.10	0.04	
Control (no spray)	2.48	4.57	43.2	4.20	0.40
SE ±	0.24	0.26	0.9	0.07	0.01

[A] Mean insect population per plant in each treatment.
[B] TSDKS stands for Twin spinning-disc knapsack sprayer.

Table 2 Effect of different sprayers on control of fungal diseases[A] in groundnut varieties, ICRISAT Center, rainy season 1987.

Sprayer	Chemical	ICG(FDRS) 4		ICGS 44	
type	type	Rust	LS[B]	Rust	LS
Knapsack (manual)	Bavistin	0.28	1.01	1.05	0.64
TSDKS[C]	Bavistin	0.21	1.05	2.27	1.23
Knapsack (manual)	Chlorothalonil	0.38	0.60	3.45	1.63
TSDKS	Chlorothalonil	0.53	1.33	5.10	1.95
Control (no spray)		1.11	1.94	4.52	1.88
SE ±		0.09	0.47	0.52	0.37

[A] Rust and Leaf spot diseases were scored in 1-9 scale.
[B] LS stands for Leaf spot disease.
[C] TSDKS stands for Twin spinning-disc knapsack sprayer.

Table 3. Distribution[A] of droplets at different levels of canopy in groundnut, while sprayed with different sprayers

Sprayer	Top canopy	Mid canopy	Ground level	SE ±	CV
Birky	41	33	26	6.7	40
Knapsack (manual)	41	32	27	3.9	23
Knapsack (motorised)	41	31	29	5.9	35
Hand-held (CDA)	48	25	27	11.3	68
SE ±	7.8	4.6	6.4	-	-
CV	37	30	45	-	-

[A] Expressed as % of droplet numbers obtain from the mean value of three observations.

Table 4. Requirements for spraying on groundnut by different sprayers

Sprayer	Time (h ha^{-1})		Labour	Operating cost (Rs ha^{-1})			Water
type	Spray-ing	Total	(man-hr ha^{-1})	Labour cost[A]	energy cost	Total cost	required (l ha^{-1})
Knapsack (manual)	11.2	14.0	28.0	56.0	C	56.0	500
TSDKS[B]	1.3	1.5	1.5	3.0	0.62	3.62	25
Hand-held (CDA)	2.60	3.1	3.1	6.2	1.25	7.25	15
Electrodyn	2.2	2.2	2.2	4.4	C	5.28	C
Birky	2.6	2.9	2.9	5.8	C	5.8	25
Knapsack (motorised)	5.5	8.0	16.0	32.0	6.0	6.0	450

[A] Cost of labour Rs. 16 per day (8 hours working). US $ 1 = Rs. 13.
[B] TSDKS stands for Twin spinning-disc knapsack sprayer.
[C] Cost estimations for Electrodyn, Birky and motorised Knapsack are not reported since these were imported and their costs are not comparable with the other sprayers purchased from local market.

mask should provide sufficient protection. The need for provision and use of protective clothing is not well appreciated in many developing countries. Caution should be exercised before recommending the adoption of ultra low volume devices, unless proper precaution is ensured against operational hazards.

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