



A New Technology for Improved Pesticide Coverage on the Cotton Canopy. Part I: Sprayer Development

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ABSTRACT

Insect control in cotton fields should comply with the new demands for reduction of pesticide toxicity and environmental hazard. In order to meet these demands, a new technology capable of delivering very high spray deposition uniformity was developed and tested. Penetration of the spray into the dense cotton canopy was achieved utilizing fast air streams, while efficient deposition was achieved by a slow and turbulent airflow close to the canopy parts. Sharp decline in the air velocity was achieved by narrow air curtains, generated from outlets in the form of long and narrow slits. Based on the experience that the upper sides of the leaves are much better spray collectors than the underside, air deflectors at the air outlets were designed to create upward velocity components and to enhance spray deposition on the undersides. Field tests showed that the new sprayer delivers far better uniformity of spray deposition in cotton fields than do conventional sprayers.

Introduction

Recent trends in agriculture require reduction in both the toxicity of the pesticides and the applied dosage, in order to reduce hazard to non-target species, the grower and the environment. The recommended dosage of a pesticide is usually defined so as to provide the required control. If the application uniformity is very poor there are sites on a plant where only very small amounts of the chemical are deposited. Thus, the total dosage is set to reach the required levels in these locations unless the pest or the pesticide is mobile. Materials with very low toxicity were developed in a complementary research study (Veierov, 1996). These materials were not effective unless applied uniformly all over the plant.

The use of air-carried spray for transport and penetration of droplets into the plant canopy can improve efficiency and uniformity of spray deposition (Matthews, 1979). Considering that plant canopies are targets of variable geometries (Bache, 1985), the development of a spray system with high uniformity for all canopies is unrealistic. This work focused on uniform deposition of spray in cotton fields that are massive consumers of spray chemicals.

Preliminary experiments for application of chemicals composed of detergent (LQ-215 manufactured by Zohar Dalia, Israel) and oil compounds showed that efficient control of the whitefly was achieved only when more than 80% of the plant surfaces were covered (Frankel *et al.*, 1991). Such a high level of coverage was not achievable with the commercial sprayers that were tested. A pulsed-air technology had been developed for tomato pollination (Nahir *et al.*,

1984). Sprayers utilizing steady streams and pulsed air-streams to carry the droplets, were tested in a tomato greenhouse prior to tests in cotton fields. This technology delivered good coverage of both leaf sides due to alternation of the air velocity in upward and downward directions. The tractor mounted sprayers were operating as drop-tube sprayers with the air outlets located between the rows. They achieved leaf coverage of more than 80% on the undersides of the leaves and close to 100% on the upper-sides (Gan-Mor *et al.*, 1996). The mechanical reliability and ease of operation of the pulsed air-stream sprayers were low and require improvement.

This work was aimed at developing a reliable and simple-to-operate sprayer for cotton fields, with high uniformity of spray deposition.

Laboratory Tests on the Sprayer Design

The basic assumption of the design was that droplet deposition is efficient if the air-carried spray flow hits the targets at normal angle with a relatively low velocity. High velocities caused leaves to bend and thus not face the stream to collect the droplets. This assumption was validated in preliminary laboratory experiments. Additional experiments determined the shape of the air outlets. The optimal outlets were narrow and long and were able to form a thin air curtain. The air velocity declined very sharply after leaving the sprayer, since the thin curtain had a low mass-to-surface ratio. Laboratory tests also determined the optimal location of the spray nozzles.

Figure 1a shows the design of the first prototype drop-tube with pulsating-air jets, for spraying between the cotton rows. Figure 1b shows the design of the second

prototype drop-tube with short-slits. Figure 2 shows the third and optimal design of drop-tube with triangular cross-section where the nozzles are mounted behind and protected by the back of the triangle (Israel patent pending No. 112599). This design has internal air-deflectors at the air outlets that provide an upward velocity component to face the underside of the leaves. This facilitates deposit of the spray on the undersides since, as discussed above, low velocity air-assisted spray is efficient when the target is facing the stream.

To ensure reliability of the spray nozzles, simple and common hydraulic nozzles were used. A co-ordinates table was used to determine the optimal location and angles of the nozzles. The spray nozzles that provided optimal performance in the laboratory experiments were Conejet x 3 (Spraying Systems, USA), with hydraulic pressure between 2 and 5 bars.

An overall view of the air-assisted drop-tube sprayer for cotton fields is shown in Figure 3. The sprayer is composed of a main blower that supplies the air through air ducts to the drop tubes.

Field Tests

Methods and materials for the field tests

The field tests aimed at evaluating the configurations that had given the best results in the laboratory. The performance of the new air-assisted drop-tube sprayer was also compared with drop-tubes with no air-assistance, with over-the-canopy low-volume commercial air-assisted spraying, used as a reference and an over-the-canopy hydraulic sprayer as a second reference. The first prototype pulsed-air-stream sprayer provided a high standard reference.

The various drop-tubes were mounted on a horizontal boom, so that the cotton rows with 97 cm between centres, were treated simultaneously from both sides. The tests were conducted in a cotton field with a dense canopy, 16 - 19 weeks after seeding. A 1% fluorescent tracer (Saturn Yellow, Fiesta Colours, UK) was used to monitor the covered area, defined as the percentage of leaf area that is covered with spray, and the cover density, defined as the number of droplets per unit area. These values were assessed by counting the droplets under ultra-violet light. The volumes applied were the recommended volume of 80 l/ha for the air-duct sprayer and higher volumes with the drop-tube sprayer (200 and 500 l/ha).

Results of the Field tests

Spray depositions on cotton plants for the various sprayers described above were evaluated in the field tests. The sprayers were tested with cotton var. Acala that is known to have minimal branch crossing between rows, so the drop-tube did not damage the cotton branches. The back side of the drop-tube protected the nozzles, so they were not damaged either. The covered areas on leaves for drop-tube prototype No. III, drop-tube with no air assistance, air-duct and

hydraulic boom sprayers are shown in Figure 4. Leaves were sampled at three plant heights and their upper and lower surfaces were counted separately. For each data point, four replications of 10 leaves each were taken. The results for the drop-tube prototype No. III were similar to those for No. I.

The cover densities for the air-assisted drop-tube (prototype No. III) and for the drop-tube with no air are shown in Figure 5. The other sprayers provided similar cover densities on the upper leaf surfaces in the upper parts of the plants, but as few as 5 droplets per cm² on the lower leaf surfaces in the bottom parts of the plants. The runoff values were 16%, 13% and 1% for the air-duct, hydraulic boom and air-assisted drop-tube sprayers, respectively. This indicates a high uniformity and even droplet distribution for the drop-tube sprayer.

Discussion and Conclusions

A new air-assisted drop-tube sprayer for uniform spray deposit in cotton fields was developed and tested. The triangular shape of the drop-tube was efficient in emitting the air-assisted spray as well as in protecting the spray nozzles. The thin air curtains penetrated the canopy and then their speed decayed sharply to provide low velocities close to the target. Relatively low air velocities in the target vicinity were efficient in depositing the spray, when an upward velocity component was facing the target of the leaf underside. The deposition uniformity was very high, resulting in very little runoff. Generally, the new sprayer provides greater uniformity of spray coverage on cotton compared to conventional sprayers but commercial implementation requires more experiments and operational improvements.

Acknowledgements

This work was supported in part by the Common Fund for Commodities and the International Cotton Advisory Committee and by ARO - contribution No. 717/98.

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Figure 1. Drop-tubes with air-assisted spraying technology:
(a) prototype I with pulsating air jets; and
(b) prototype II with short slits.

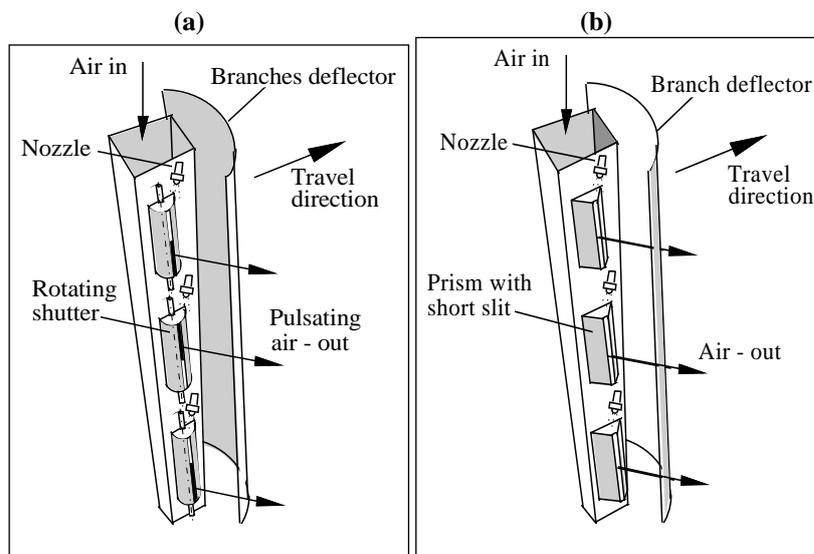


Figure 2. Prototype III of a drop-tube, with a triangular cross-section where the back of the triangle protects the spray nozzles. Narrow air streams are emitted from two side slits with an upward velocity component. There are air slits and nozzles on both sides of the drop-tube but only one is shown in the sketch.

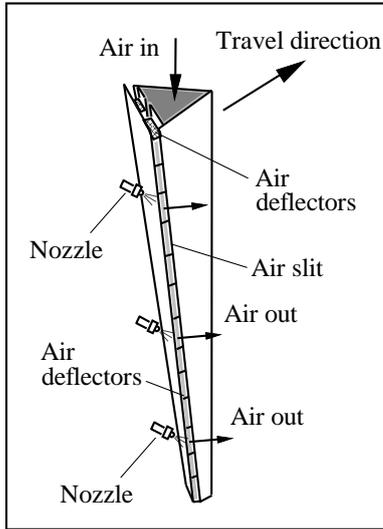


Figure 4. The covered area found in the field tests on the upper (U) and lower (L) surface of leaves located at the top (T), middle (M) and bottom (B) of plants, as recorded in field tests of: Boom, Air-duct, Vertical boom (drop-tube with no air) and Drop-tube (model No. III) sprayers.

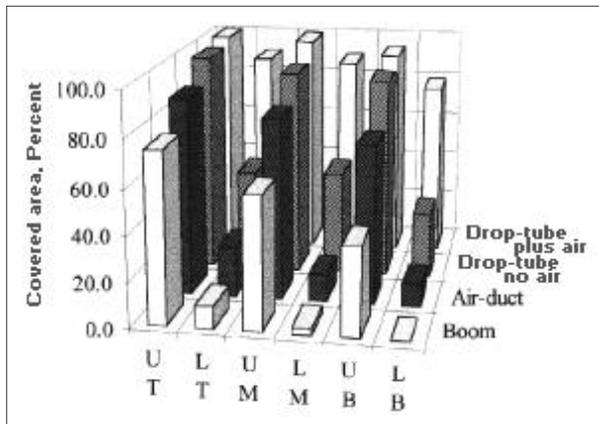


Figure 3. Overall view of the drop-tube sprayer where the tube's edge is located 20 cm above the ground while spraying.

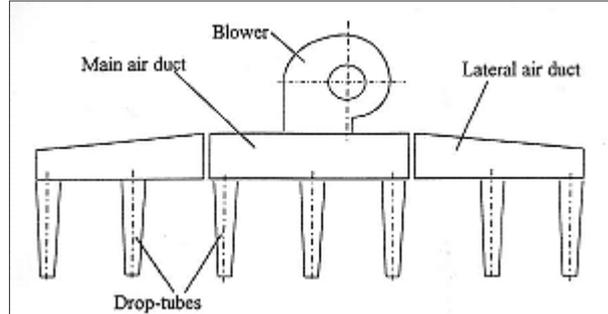


Figure 5. The cover densities found in the field tests on the upper (U) and lower (L) surfaces of leaves located at the top (T), middle (M) and bottom (B) of plants, as recorded in field tests of the sprayers: the drop-tube (model No. III - with air-assistance) and the vertical boom (drop-tube with no air).

