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The Collection Efficiencies of Spray Volumes by Desert Locust (*Schistocerca gregaria*)

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Abstract: Although FAO specifies a particular range of droplet sizes for desert locust control-VMD should be between 50 and 100 μm; this is a huge range (eight-fold) of droplet volumes. This study was used to other specialist facilities at IPARC (low speed wind tunnel, spinning top droplet generator and image analyser) to try to refine these recommendations to a narrower range of desirable droplet sizes. One of the objectives of this study was to obtain data that might suggest changes in operational parameters, which could lead to the minimization of the off-target drift that primarily arises from the small droplets produced during atomization. The analysis of data has revealed some interesting trends that were not otherwise apparent. Grouping the data from several experiments has helped to increase the reliability of the results.

Key words: Spinning disc, ULV sprayer, droplet size, collection efficiencies, batteries, locust

INTRODUCTION

Most agrochemicals are applied as liquid sprays, with the spray liquid broken up to be distributed over the target area. Whilst it is obvious that no benefit will result from dumping the entire volume of spray liquid in one spot, it is not so obvious that breaking up the spray liquid unevenly - and thus also getting uneven distribution of the spray liquid over the target area - can be nearly as wasteful. This waste not only costs money but results in unwanted and unnecessary contamination of the environment.

For most spray applications there are particular spray droplet sizes, which will be most effective in hitting the target and achieving the desired biological result. In pesticide application, for example, different pests present different targets depending on their size, location and behaviour, thus different spray droplet sizes will be best for different applications.

It was recognised that in any sprayer, droplet size is the most important controllable parameter. It influences the distribution of the spray downwind (small droplets are carried further and can therefore produce a wider swath), losses as fallout (large droplets sediments on to the soil) and the impaction efficiency on locusts and vegetation (very small droplets impact less efficiently). As a result, the size of droplets influences work rate and biological efficacy of the pesticide. It can also influence the environmental impact of the spraying operations. For example there may be negative impact if spray consisting of large droplets falls in overdosed stripes in the target area or alternatively spray consisting of very small droplets drifts out of the target area to deposit elsewhere.

If it is presumed that there is an optimal droplet size for each pest control situation then droplets larger or smaller than this size will be less effective. However, there are two problems with acting on this assumption: there is very little scientific data to indicate what the optimum droplet size is for each situation and even if there were, there are no commercial sprayers at the moment which can produce uniformly sized droplets[1].

Matthews *et al.*[2] suggested that to reduce hazards for operators and the environment, FAO has published minimum requirements for pesticide application equipment used in conventional field crop spraying. This study help to produce guidelines for specialised locust spraying equipment. According to Ould Babah[3] in locust control, ULV sprays are most common, both as ground and aerial application. Because of its toxicity, stability in the environmental and low efficacy against locusts compared to other organophosphates, e.g. not efficient against swarm. Application rates of fenitrothion should be limited to those recommended. The FAO recommended application rate against desert locust is currently 0.5l ha^{-1} with % ULV. However, recent research has shown that even lower rates (0.2l ha^{-1}) had the same efficacy[4]. Al Darmaki and Harthy[5] observed that one of the benefits of having a larger list of effective products is that they may have alternative uses in other branches of agriculture.

In order to make efficient, economic and responsible use of pesticides (conventional and microbial), it is important to have a reasonable idea of amounts of pesticide falling on the target pest, on the plant, soil or being carried away by the wind so that application parameters should be adjusted for best targeting of the product. Monitoring is not an easy task and has

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consequently often being overlooked - the farmers, extension workers and ministry of Agriculture officials have to trust that the equipment and spraying technique used will carry most of the pesticide to its target to little off - target drift or wastage.

Any system of combating the desert locust must take account of the nature of the populations we have to deal with and their behaviour. Any alternative to spraying pesticides that uses the same application technique will face the same difficulties as pesticide treatment. If an alternative avoids those application problems, the feasibility of the new method must be compared with the difficulties of spraying pesticides. A new method will be likely to be a non starter if it is logistically more difficult, more risky or more expensive than spraying pesticides.

The application of pesticides is still very poor in Pakistan and in many other countries too. Ahmed[6] noted that most sprayers in use are defective, so the government should concentrate efforts to improve the quality of plant protection machinery and arrange training of farmers to improve the application of pesticide.

MATERIALS AND METHODS

This study was completed at International Pesticide Application Research Centre, Imperial College London from February 2003 to February 2004 by the help of FAO (UN).

For assessing deposition efficiency of different droplet sizes on locusts in different airspeeds, a low speed wind tunnel was used. This device was developed at NRI in the late 1980s and the designs passed to IPARC for replication there in the 1990s. It consists of a fan box to draw air, a working section, which the air and the droplets pass through and an inlet where the droplets are drawn in. Droplets were produced by commercial spinning disc sprayers.

Tachometers: Manual and electronic tachometers were used to test the rotational speed of rotary atomisers.

Calibration of the tunnel and atomizer: Tunnel airspeeds were measured using a thermal anemometer (Model TA400T, Airflow Developments Ltd). A flexible diaphragm on the side wall of the tunnel allowed the small probe to be inserted and positioned without significant disturbance of the airflow, so that the uniformity of flow could be checked. Movement of droplets in the working section was observed under ultraviolet illumination and a grid of fine wires suspended across the working section was used for sampling to evaluate uniformity. Atomizer position, inlet geometry and disposition of the flow-regulating gauze were all modified until satisfactory uniformity was achieved over the central 0.20×0.20 m of the working section.

Monodispersed droplet production: For monodispersed droplet production, a vibrating orifice generator (Model 3050, TSI)[7] was available in the international pesticide application Research Centre but unluckily, it was out of order in spite of all effort. There was no other device available. So keeping in view the shortage of time, I used Micron ULVA + yellow nozzle which was generating the droplets of more uniform sizes. ULVA + was set just ahead of the tunnel entry (optimum positioning for uniformity of distribution in the working section formed a part of the calibration procedure). Formulation consisting of Edelex oil 50%+ odourless Kerosene oil 50% was used to produce droplets of 58 μm in the working section when the atomizer flow rate was adjusted to 30 mL min^{-1}.

Experiment: Dead adults of *Schistocerca gregaria* were mounted in simulated resting positions on front side rear of vertically. Supported by brass tubes 0.635 and 2.54 cm in diameter simulating twig and branch resting sites. Each locust was secured by a pin through the thorax embedded in a bead of conducting plasticine. A glass slide 6.3 mm long was also hanging with the locust as a control. Spray the sodium fluoride (dye) added solution of 50% Edelex oil+ 50% odourless kerosene oil for 10 seconds. Yellow nozzle was added the dye at the rate of 0.5 g L^{-1} was used due to minimum flow rate (30 mL min^{-1}) and more uniformity of droplets. Put 100 mL of water in each beaker and place the locust and glass slide separately in each beaker after removing from wind tunnel. These beakers with locust and glass slide were placed in the incubator shaker at 20 C° for 10 min at 150 rpm.

Take blank solution in the cuvette tube and place it in the reading box of florimeter and adjust the reading number as 0.00 for standard reading. Same cuvette tube was used for all the reading to avoid any error with other tube. Take the concentrated solution of each wash of locust in the cuvette tube and place it in the florimeter for score reading. Locust and glass tube were washed clean of deposits with water after each run and after dry up the locust, replaced in the wind tunnel. Same locust was used for same position during the experiment to avoid an error due to size difference of locust. A freshly pinned specimen was placed if in any way damaged. Measurements were made at three wind speeds (1, 2 and 3 m sec^{-1}).

Each experiment repeated for four times for the mean accuracy of the experiment.

RESULTS AND DISCUSSION

A low speed wind tunnel was used to measure the collection efficiencies of the various component parts of adult *Schistocerca gregaria* Desert locust when at rest on cylinders, simulating the branches and twigs of the natural habitat.

Figure 1 showed that 23 μL spray volume was collected at vertical (head upward) positions as compared to other positions. Side position of locust received 8 μL of spray volume; rear received 4 μL; front received 2 μL and control (glass slide) received 5 μL at 1 m sec^{-1} air speed. When I increased the airspeed at 2 m sec^{-1}. The collection efficiency was rapidly increased. At this air speed the vertical body part of locust received 28 μL volumes and much difference was observed at side position of locust, which collected 22 μL of spray volume. It showed that 14 μL of more volume was received when air speed increased from 1 to 2 m sec^{-1}. The collection efficiencies at rear; front and glass slide were negligible at 2 m sec^{-1}.

The highest collection efficiency was observed at 3 m sec^{-1} air speed. There was also a steady increase in the collection efficiencies at all body parts. The highest volume 42 μL was again collected at vertical position of desert locust in wind tunnel. The other, much volume of spray was collected at side way position of locust.

It was also observed that collection of spray droplets at glass slide (Control) was increased by increasing the airspeed of wind tunnel. The control (glass slide) received 5 μL of spray volume at 1 m sec^{-1}; 8 μL of spray volume at 2 m sec^{-1} and 14 μL of spray volume at 3 m sec^{-1} air speed. This showed a linear tendency of much volume collection at increased in number of batteries. Like the control (glass slide), all the positions of desert locust received a much volume at increased number of batteries.

The effective time available was restricted to an approximately 3 h period in the morning when the wind-speed was >2 m sec^{-1} and the ground temperature was <30°C. Under these circumstances, ULV drift spraying is the only feasible method of application and there is considerable pressure to reduce volume application rates well below 1 L ha^{-1} in aerial operations. Other techniques for improving work rate, including the use of global positioning systems, are discussed by Dobson[8].

Figure 2 showed that 41 μL of spray volume was collected at vertical (head upward) position at 1 m sec^{-1} air speed. There was a manifold increase in the collection efficiency was observed at 2 m sec^{-1} and 3 m sec^{-1} airspeeds, which were 52 μL and 69 μL spray volumes, respectively. The side position was second important part which received maximum volume of spray droplets, 32 μL at 1 m sec^{-1}; 50 μL at 2 m sec^{-1} and 57 μL of spray

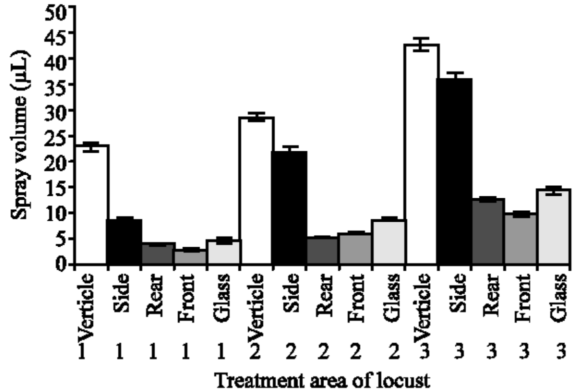

Fig. 1: Collection of spray volume by desert locust using rotary atomizer sprayer with 5 batteries

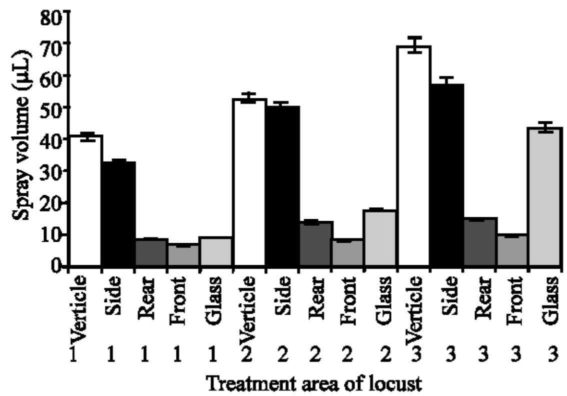

Fig. 2: Collection of spray volume by desert locust using rotary atomizer sprayer with 7 batteries

material at 3 m sec^{-1} airspeed. Rare position of desert locust collected 8 μL at 1 m sec^{-1} airspeed; 14 μL at 2 m sec^{-1} and 15 μL spray material at 3 m sec^{-1} airspeed. Front position of body parts received 6 μL at 1 m sec^{-1} airspeed; 8 μL at 2 m sec^{-1} airspeed and 10 μL at 3 m sec^{-1} airspeed of wind tunnel.

The results were in agreement with those of Johnstone *et al.*[9] who investigated dose, deduced from measurements of Q determined by the droplet measurements obtained from a rotary slide sampler and compared the results with those determined flourimetrically on samples of wild flies caught very soon after spraying. This is very satisfactory agreement between predicted and measured deposition indicates that by using numerical values of collection efficiency in interpretation of the monitoring sampler data, we now have a powerful method of quality control on the application, in terms of the required outcome, namely the expected lethal effect on the flies.

Again a steady increase was noted in the collection efficiencies of Control (glass slide), which collected 8 μL at 1 m sec^{-1}; 18 μL at 2 m sec^{-1} and 44 μL spray volumes at 3 m sec^{-1} airspeed. In all the cases of spray collection it was observed that vertical position of locust received a maximum volume of spray and it was also very interesting to note that by increasing the air speed, a maximum volume of spray material was collected on the locust body.

These results were favoured by Hinds[10], who found a large difference in collection the efficiency were apparent between the different deposition zones examined, ranging from 380% for the antennae (with 25 μm droplets, in a 1.5 m sec^{-1} airstreams) down to zero (or near zero) for the abdomen in dorsal (F) presentation (a number of zeros were recorded for various zones when the flies were mounted at the rear of the cylinders). The antennal setae constitute an array of tapered cylindrical collectors of very small diameter (average diameter of about 15 μm, or the same of size as of the droplets), so that the additional collection by interception appears to account for the values in excess of 100%. Although the antennae were the most efficient and the abdomen the least efficient individual sites, it is the larger area sites, e.g. thorax, abdomen, wings and legs, which carried the most weight, in terms of the contribution to the overall collection efficiency of a fly. The results were in agreement with those of Johnstone *et al.*[9] who investigated dose, deduced from measurements of Q determined by the droplet measurements obtained from a rotary slide sampler and compared the results with those determined flourimetrically on samples of wild flies caught very soon after spraying.

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