Effect of formulation of crop protection products on drop size at different distances when using a Low Volume Mister in greenhouses

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van de Zande, J.C.; Porskamp, H.A.J.; Holterman, H.J.

EFFECT OF FORMULATION OF CROP PROTECTION PRODUCTS ON DROP SIZE AT DIFFERENT DISTANCES WHEN USING A LOW VOLUME MISTER IN GREENHOUSES

Jan C. van de Zande(correspondence), Henk A.J. Porskamp, Henk Jan Holterman

Institute of Agricultural and Environmental Engineering IMAG B.V., P.O. Box 43, 6700 AA Wageningen, The Netherlands

SUMMARY

A Phase-Doppler anemometer was used to quantify drop sizes in the spray cloud of a Low Volume Mister (LVM). Measurements were performed for 6 different formulations and tap water. The selected formulations were a fungicide, an insecticide, an insecticide-adjuvant mixture and three biocides, of which one was mixed with an adjuvant. Drop sizes were measured at 0.5m, 5m and 10m distance from the LVM in a conditioned room at constant temperature and humidity.
Results show that large differences occur in drop size between formulations. At 0.5m distance Volume Median Diameter (D_{v50}) changes from 30µm for tap water to 25µm for fungicide and insecticides and 18µm for one of the biocides. For two biocides VMD was equal to water. At 5m and 10m distance it is shown that drop size changes with time. A large change in drop size is observed after the application has stopped. In general drop size after spraying reduces to about 6µm. These small particles vanish eventually because of ventilation of the room. At 5m and 10m from the LVM it was also shown that the number of drops per unit time differs for different formulations. It was concluded that formulation has a large effect on spray quality produced by a Low Volume Mister.

Key words: drop size, drop density, VMD, Low Volume Mister, formulation

INTRODUCTION

Nowadays crop protection in greenhouses is more and more done with biological products. The application technology however did not change. Both plant directed applications and space applications are performed (1). Especially insecticides are most often applied as a space application using cold foggers (Low Volume Mister) generating aerosol droplets (2). These fogs of spray are distributed throughout the greenhouse using ventilators mounted on the spray device or on fixed positions in the greenhouse. It is shown (3,4) that the formulation of agrochemicals has its effect on drop size when using flat fan nozzle types. Little is known about drop sizes when applying agrochemicals with cold foggers like a Low Volume Mister (LVM). This paper describes a research setup to assess the effect of new biological formulations and commonly used agrochemicals in greenhouse crop protection on drop size and distribution when using a LVM. Measurements were performed for 6 different formulations and tap water. Drop sizes were measured at 0.5m, 5m and 10m distance from the LVM in a conditioned room at constant temperature and humidity.

METHODS AND MATERIALS

Low Volume Mister

The sprayer used was a Low Volume Mister (Enbar, Brinkman) commonly used for space applications of pesticides in greenhouses in The Netherlands. The sprayer is equipped with two Air Atomisers (1153-70 Spraying Systems, Wheaton, Ill.), only one of which was used during the tests. Air pressure during the experiments was 6 bar. Flow rate of the nozzle was 0.08 L/min. Nozzles were placed 0.75m above the ground surface, spraying horizontally, in front of a fan, which could be switched on/off for measurements with and without air assistance. Fan diameter was 0.3m, and air capacity was 2000 m^3/hour.

Spray Solutions

Drop size measurements were performed for 6 different formulations and tap water. Selected formulations included were a fungicide, an insecticide, an insecticide-adjuvant mixture and three biocides of which one was mixed with an adjuvant (Table 1). Mixtures were made in a 4L container that could be directly coupled to the LVM sprayer.

TABLE 1. Spray solutions used for drop size measurements.

Spray solution	product	Volume concentration	
		product	Water
Water			**4000ml**
Biocide A	**Vital + Agral**	**400 + 4 ml**	**3596 ml**
Biocide B	**Spot-X**	**75 ml**	**3925 ml**
Biocide C	**Citronella oil**	**50 ml**	**3950 ml**
Fungicide A	**Fungaflor**	**50 ml**	**3950 ml**
Insecticide A	**Decis**	**100 ml**	**3900 ml**
Insecticide B	**Decis + Ekomist**	**100 ml + 160 ml**	**3740 ml**

Drop Sizing

Drop size measurements (5) were done using a Phase-Doppler Particle Analyser (PDPA, Aerometrics, Sunnyvale USA). The PDPA was set-up to measure sizes of drops passing in the horizontal plane. Measurements were done at 0,50m distance from the nozzle in the centre of the spray fan (0.75m height). Measurements were performed both with the fan of the sprayer off and on (maximum capacity). Measurements lasted until 175000 drops were counted. Three replicates were measured. Results are presented as the Volume Median Diameter (VMD = D_{V50}) and the dropsizes of the 10th and 90th percentile of the volume distribution ($D_{V10,}$ and D_{V90}). For Biocide A and Insecticide A measurements were also done at 5m and 10m distance from the LVM. Drop size measurements were done 0.75m from the ground with the fan on. Measurements lasted 10 minutes during spraying and lasted another 15 minutes after stopping spraying. For water 3 replicates were measured during spraying. During spraying of the other mixtures a single measurement was done. After stopping the sprayer only a single measurement was done. The VMD and the number of the drops per second passing the sampling volume of the PDPA are presented.
Measurements took place in the IMAG spray laboratory, in a temperature and humidity controlled chamber of 14m long, 5.5m wide and 3.5m high. Temperature was

maintained at 20°C and air humidity at 70%. During the experiments the air-conditioning system of the spray chamber was switched off, to prevent interference with the air flow from the ventilation system. After spraying the air of the spray chamber was refreshed before starting a next experiment. Ventilation rate of the air was 12 times per hour.

RESULTS

The results of the drop size measurements on 0.5m distance from the nozzle are presented in Table 2. The measurements were done in triplicate. The difference in D_{v50} within repetitions was less than 2 μm.

TABLE 2. Drop size distribution (D_{V10}, D_{V50} and D_{V90} μm) of different spray solutions when spraying with an ENBAR LVM, at 0,5m of the nozzle with the fan switched on or off.

Spray solution	Fan	D_{v10} [μm]	D_{v50} [μm]	D_{v90} [μm]
Water	**off**	**13.0**	**30.9**	**66.0**
Biocide A	**off**	**9.9**	**18.2**	**74.6**
Biocide B	**off**	**13.5**	**31.3**	**64.2**
Biocide C	**off**	**12.7**	**28.7**	**63.4**
Fungicide	**off**	**11.6**	**24.8**	**55.3**
Insecticide A	**off**	**11.9**	**25.7**	**59.2**
Insecticide B	**off**	**11.4**	**25.1**	**55.0**
Water	**on**	**12.5**	**26.4**	**59.3**
Biocide A	**on**	**9.2**	**15.9**	**72.3**
Insecticide A	**on**	**11.3**	**21.4**	**50.8**

It is shown that all spray solutions do have an equal or finer spray quality than tap water when sprayed with the LVM. Whereas for tap water the VMD is 30.9μm, it decreases to around 25μm for the insecticides and the fungicide solutions (a size reduction of 20%) and down to 18.2μm for Biocide A (a size reduction of 42%). For Biocides B and C the VMD was comparable to the VMD of the water. For water, Biocide A and Insecticide A the effect of the airflow of the fan on drop size was measured too. For these solutions it can be concluded that the airflow of the fan reduced drop size significantly by on average 15% measured at 0.5m distance from the nozzle, in the centre of the spray plume.

Results of the drop size measurements (VMD) during and after application (0-600 sec.) are presented in Figure 1 for the distance 5m from the nozzle and Figure 2 for 10m distance from the nozzle. At 5m distance a comparison is made between tap water and Insecticide A and at 10m distance for water, Biocide A and Insecticide A. These were single measurements. In both figures also the number of drops passing the measuring volume of the PDPA is presented. This value gives an idea of the drop density in the air on these distances.

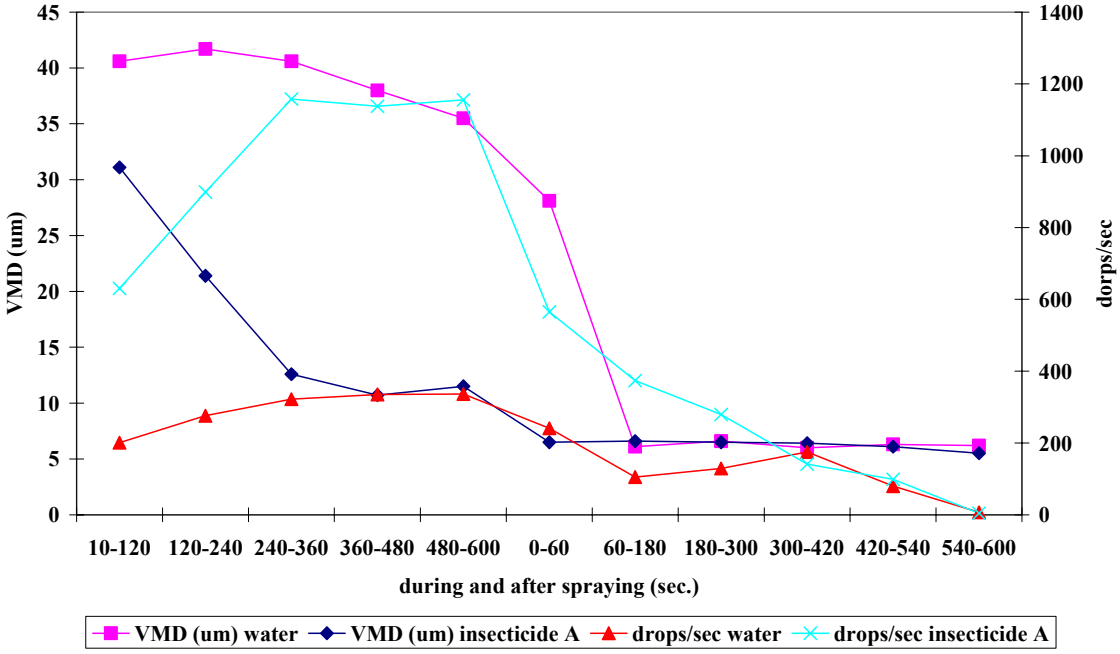

FIGURE 1. Volume Median Diameter (µm) and drop density (drops/second) of the spray passing at 5m distance from the nozzle in a conditioned room (20°C, 70% RH), when spraying water and Insecticide A with a Low Volume Mister (Enbar) during and after spraying

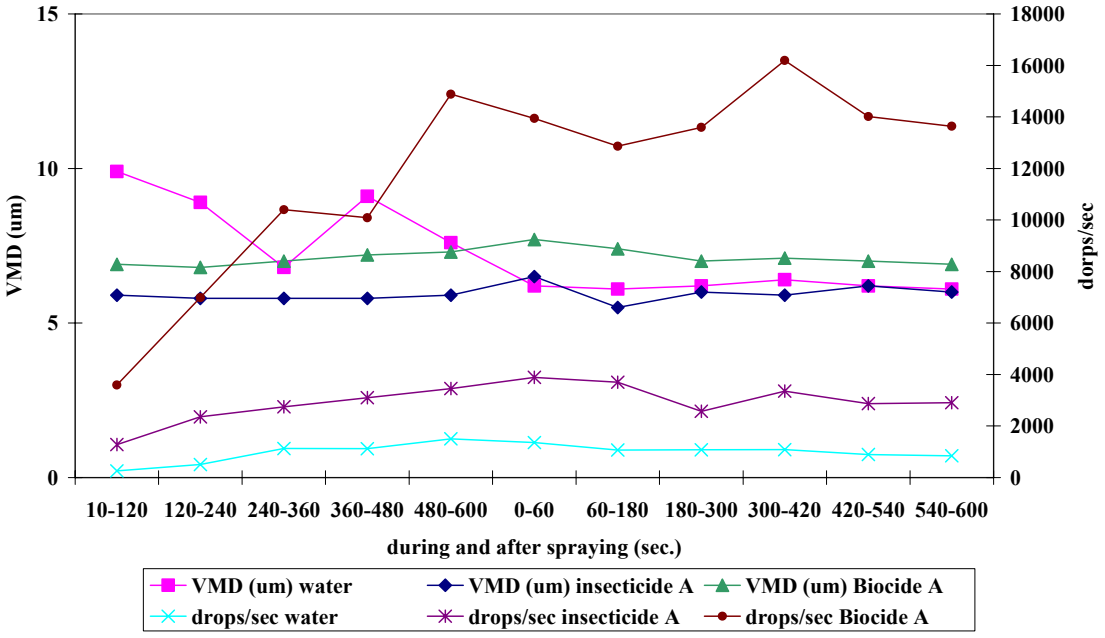

FIGURE 2. Volume Median Diameter (µm) and drop density (drops/second) of the spray passing at 10m distance from the nozzle in a conditioned room (20°C, 70% RH), when spraying water, Insecticide A and Biocide A with a Low Volume Mister (Enbar) during and after spraying

Both at 5m and at 10m distance it is shown that there is an effect of spray solution on Volume Median Diameter and drop density. During spraying the VMD of Insecticide A is at 5m distance from the nozzle lower than for water. After stopping the application VMD decreases to a value of 6μm for both water and Insecticide A. This value remains stable at least for 10 minutes (600 sec). It seems there is a permanent airborne fraction of small drops of this size in the air of the chamber. Drop density of Insecticide A is on average three times higher than of water.
From the decrease in VMD during spraying with time (0-600 sec) it is expected that an increasing number of these small drops are being measured during application. The number of drops detected in the air is for Insecticide A higher than that for water.
At 10m distance the Volume Median Diameter of water is higher during spraying only for the first 360 seconds. Thereafter VMD is the same for water, Insecticide A and Biocide A. After stopping spraying VMD remains at the same level for the three spray solutions (5-7μm). Drop density is lowest for water. Both during and after spraying the drop density at 10m distance from the nozzle is higher for Insecticide A and Biocide A. Drop density for Insecticide A is on average three times higher and that of Biocide A twelve times higher than that of water.
The rapid decrease in VMD for water shows that an increasing number of permanently present small drops are influencing the measurement. During application a mist of drops is developed of more or less equal sizes (5-7μm). Due to constant refreshment of air by the air-conditioning system, drop density decreased to nil eventually.

DISCUSSION

Spray solution has its effect on drop size when sprayed with a Low Volume Mister. Measured in the spray fan at 0.5m distance from the nozzle all solutions show an equal or finer spray quality than when using tap water. The Volume Median Diameter decreases from 30.9μm for tap water down to 18.2μm for a Biocide, a size reduction of 42%. When the fan of the LVM is turned on, drop sizes get smaller for all solutions measured. In general a decrease in VMD of 15% occurs, measured at 0.5m distance from the nozzle, because of the airflow.
Both at 5m and at 10m distance it is shown that there is an effect of spray solution on Volume Median Diameter and drop density. During spraying the VMD of Insecticide A is lower than for water. At 5m distance VMD of Insecticide A decreases faster in time during spraying than of water. After spraying VMD of water decreases to the level of that of Insecticide A. At 10m distance the VMD of water is higher during spraying only for the first 360 seconds. Thereafter the VMD is the same for water, Insecticide A and Biocide A. After spraying VMD remains at the same level for the three spray solutions (5-7μm).

When spraying with a LVM in a closed room the air will be filled with small drops in short time, a mist is created. These drops will deposit, evaporate or remain airborne for a period of time. These airborne small drops can influence the drop size measurements, as they pass through the measuring volume of the laser more than once during measuring time. This does not happen at short range from the nozzle (0.5m) but could be of influence on the measurement at 5m and 10m distance. From the measurements after spraying stopped, it can be concluded that the airborne drops have a size of around 5-7μm, with no difference between the spray solutions. Especially this fraction of

remaining airborne drops can lead to emission from the greenhouse of the crop protection product. In this respect ventilation rate of greenhouses (6) and time of opening of the windows after spraying (7), to prevent heating of the crop and clean the air to re-enter the room, is of importance irrespective of the volatilisation characteristics of the crop protection product.

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