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Evaluation of the effect of spray pressure in hand-held sprayers in a greenhouse tomato crop

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ABSTRACT

In greenhouses, plant-protection products are usually applied by hand-held high-pressure spray guns or lances spraying at high volume rates. This low-technology equipment produces a deposit distribution of low uniformity on the plant canopy, heavy losses to the soil, and high exposure risk to workers. The aim of the present work was to evaluate the effect of spray pressure on deposition and losses to the ground using a hand-held spray lance in a greenhouse tomato crop. Spray applications were made at three different pressures (1000 kPa, 1500 kPa and 2000 kPa) in two developmental stages of a tomato crop. The results show that for the applications at the highest pressure, the average deposit was between 22.5% and 34.6% less than at the two lower pressures. Also, the use of high pressures such as 2000 kPa hampered penetration into the plant canopy, with deposition values in the inner zones of the canopy of between 9.4% and 37.4% less than when pressures of 1000 kPa and 1500 kPa were used. Nevertheless, the losses to the ground for the highest pressure were between 10.3% and 24% lower than for the two lower pressures.

1. Introduction

The surface area dedicated to the cultivation of greenhouse vegetables in Almería (south-eastern Spain) has increased markedly in recent years to some 29,990 ha, with the province of Almería (Spain) becoming one of the largest producers of table vegetables in Europe, reaching 2,973,614 tonnes in the 2011/2012 (Cabrera and Uclés, 2012). The greenhouse production system in south-eastern Spain is characterized by high planting densities, high temperatures, and high relative humidities. These conditions cause a high incidence of pests and diseases that are usually controlled by chemical products.

Currently, the agrofood industry, and more specifically the horticultural sector, is seeking the production of quality foods by safe and sustainable procedures. This has given rise to the development and use of less aggressive methods, notably the integrated control of pests. Nevertheless, the use of plant protection products (PPP) continues to be the most widely used alternative to satisfy the demands of the food market, and therefore it demands the rational use of PPP.

One of the factors that most influences the optimisation of a PPP treatment is the application equipment used (Pergher et al., 1997; Cunningham and Harden, 1998; Farooq and Salyani, 2002; Salyani et al., 2006; Braekman et al., 2009, 2010). In greenhouses, PPP are applied mainly by manual systems involving spray guns or lances. Such equipment is used in 91.7% of the greenhouses in south-eastern Spain (Céspedes-López et al., 2009), in 70.5% of the greenhouses in Flanders (northern Belgium) (Goossens et al., 2004) and in 71% of the greenhouses in Italy (Cerruto et al., 2009a). Normally, applications with this type of equipment are made at high pressure (>2000 kPa), distributing large volumes of water to the point of run-off.

Other types of application equipment are used in greenhouses to a lesser extent, such as trolleys and self-propelled vehicles with vertical spray booms. The dominant use of manual application (spray guns and lances) is due to the low cost of the equipment, easy maintenance, and the flexibility to adapt to different planting schemes and greenhouse layouts. However, this manual equipment has disadvantages, such as the light deposition and uneven distribution of the PPP on the plant canopy, heavy losses to the soil (Sánchez-Hermosilla et al., 2011, 2012), and the serious chemical-exposure risk of the workers (Nuyttens et al., 2004a, 2009a). In addition, with this equipment, the skill of the user strongly determines the efficiency of the treatment (Derksen et al., 2008).

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Fig. 1. Spray lance with two twin flat fan spray nozzles.

Fig. 2. Spray lance with four twin flat fan spray nozzles.

As commented previously, hand-held sprayers are usually used at high pressures (>2000 kPa), due to the security that this offers the farmer to see a cloud of spray cover the crop. However, there is no technical evidence that justifies high-pressure applications. Derksen et al. (2008), analysing the effect of the volume rate and quality of the spray in spray-gun applications on greenhouse-grown Poinsettia, concluded that the use of high pressures to generate fine droplets offers no advantage over lower pressures that generate coarser droplets.

van Os et al. (2005) evaluated the effect of spraying pressure and application rate in a greenhouse tomato crop using a trolley equipped with a vertical spray boom with fan nozzles. The results showed that the deposition as well as the penetration into the plant canopy improved when the pressure was increased. However, they considered that the pressure of 500 kPa provided adequate deposition over the canopy while reducing the losses to the soil. Also, Braekman et al. (2009), in a greenhouse study of potted ivy treated by a vertical spray boom system, indicated that pressure did not affect deposition.

Taking into account the importance of the use of hand-held sprayers to apply PPP in greenhouse crops, the present work seeks to evaluate the effect of spray pressure on deposition and the losses to the ground using a hand-held spray lance in a greenhouse tomato crop.

2. Materials and methods

2.1. Spray equipment

The trials were made with a lance sprayer equipped with two or four twin flat fan nozzles (Novi Fan S.L., Almería, Spain), depending on the canopy size. This type of spray lance is widely used to apply PPP in south-eastern Spain (Fig. 1, Fig. 2).

The spray lance was connected by a hose 25 m long (17 mm in diameter), to a trolley holding a 100 L tank and a membrane pump (M-30, Imovilli Pompe S.R.L., Reggio Emilia, Italy) that provided a maximum pressure of 3000 kPa and a maximum spray volume of 33 L min^{-1}.

2.2. Experimental design

The trials were done in a multi-gable greenhouse of 960 m^2 area situated at the La Mojonera Research Institute (IFAPA, Junta de Andalucía) Almería, SE Spain, latitude 36°48′N, longitude 2°41′W, altitude 142 m. The greenhouse was 40 m long and 24 m wide (3 modules 8 m wide each), with 4.5 m wall height and 6 m gable height.

The plant material used in the trials was a tomato crop (*Lycopersicon esculentum* Mill. Cv. Vernal) grown in containers filled with perlite and planted in a twin-row system (two rows planted close together) with rows 2 m apart and 0.4 m between plants (2.5 plants m^{-2}). The water and the fertilizers were provided by an automatic system of drip irrigation, while the cultivation tasks followed local practices. The tomato seedlings were transplanted on 27 February 2012 and trials were made in two stages of development, i.e. 56 and 93 days after transplanting. The crop characteristics in the 2 trials are given in Table 1. The leaf area index (LAI)

Table 1
Characteristics of the crop.

Trial	Dat[a]	LAI	Crop height (m)	Crop depth (m)
1	56	1.56	1.47	0.78
2	93	2.93	2.62	0.82

[a] Days after transplanting.