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Assessment of the influence of working pressure and application rate on pesticide spray application with a hand-held spray gun on greenhouse pepper crops

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ABSTRACT

Choosing the appropriate machinery for applying pesticides is crucial. Despite the availability of technologically more advanced equipment, the hand-held spray gun is still widely used today for spraying greenhouse crops because of its ease of operation and its low economic cost. Growers believe that a high spray application rate and a high pressure are needed to achieve good pest and disease control. In this study, the effects of pressure and volume application rate for application of treatments using a hand-held spray gun to greenhouse pepper crops were evaluated. In the first case, three different pressures were assessed: a reference at 2000 kPa (P20) and two others at 1500 kPa (P15) and 1000 kPa (P10). To test the effects of application volume, three application volumes were used: one considered to be reference (V100), applied by an experienced grower, and two reductions thereof, i.e. 25% (V75) and 50% (V50). Each test was made at two different stages of crop development. The results showed that the use of high pressures did not improve either the deposition or the penetration into the crop canopy and the losses to the ground were not significantly different. On the other hand, a reduction by some 25% of the application rate routinely used by local farmers caused major reductions in deposition on the plant canopy, which might possibly compromise pest and disease control. The losses to the ground diminished with the application rate, although differences were not significant between V100 and V75.

1. Introduction

In Almería (S Spain), some 29,597 ha of greenhouses produce approximately 3,199,283 tonnes of different species of horticultural plants, primarily tomato and pepper (Cabrera et al., 2015). Although biological pest-control systems are on the rise, augmenting the use of beneficial insects to control pests and diseases, it is still necessary to use chemical control, whether alone or in combination with other integrated production systems.

For chemical pest control, a critical factor is the selection of the equipment to be used. For the application of pesticides in greenhouses, there are self-propelled autonomous machines (Balsari et al., 2012; Guzmán et al., 2008; González et al., 2009) as well as manually pulled trolleys equipped with vertical spray booms (Llop et al., 2015a; 2015b; Sánchez-Hermosilla et al., 2011, 2012; Nuyttens et al., 2004b), which provide good results for coverage, penetration, and uniformity. Despite the advantages of advanced machinery, the use of low-technology equipment remains widespread, including spray guns, in greenhouses in different parts of Europe, such as Belgium, Italy, and Spain (Goossens et al., 2004; Cerruto et al., 2009a; Céspedes-Lopez et al., 2009), primarily for their ease of use and low economic cost. However, such spray systems often prove deficient, being used normally at a high working pressure with excessive application volumes (Cerruto et al., 2009b), resulting ingreat losses to the soil (Sánchez-Hermosilla et al., 2011, 2012) while increasing exposure of the operator (Nuyttens et al., 2004a, 2009a; An et al., 2015; Tsakirakis et al., 2010). Therefore, it is important for this equipment to be properly calibrated and to be used correctly for a sustainable use of pesticides and thereby reduce risks to the environment and human

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health (Balsari, 1999, Fernández et al., 2012; Cerruto et al., 2008; Páez et al., 2010; García-García et al., 2016; Parrón et al., 2014).

In south-eastern Spain, the equipment most commonly used is the hand-held spray lance with a double flat fan nozzle, given that its use is somewhat more effective than those of a conical nozzle (Garzón et al., 2000). Derksen et al. (2001) observed that, on increasing the application rate, coverage improved on the upper side of the leaf but not on the underside, where the great majority of pests and diseases develop. In a study made in a tomato crop, Lee et al. (2000) identified a threshold to the application rate (2800 L ha^{-1}) beyond which deposition fails to increase. In previous studies evaluating the functioning of spray lances in a tomato crop, Sánchez-Hermosilla et al. (2013), reported that high pressures offered no advantage over lower pressures.

In the present work, the way in which working pressure and volume application rate influence deposition in the plant canopy were evaluated and also losses to the soil were assessed when a hand-held spray lance was used in a greenhouse pepper crop. The aim was to optimise application in order to make the use of this low-technology equipment as efficient as possible. For this, it was necessary to determine which working pressure performs best and whether is possible to reduce the application rate and achieve the same deposition in the canopy as with the application rate usually used by farmers.

2. Material and methods

2.1. Experimental design

The tests were conducted at the experimental farm of the Fundación UAL-ANECOOP of the University of Almería (36°52′N, 2°17′W), in a greenhouse of 1800 m^2 (45 × 40 m) bisected by a central east-to-west lane 2 m wide perpendicular to the crop rows which were 20 m long in the northern section and 18 m long in the southern section (Fig. 1). For spraying, a hand-held spray lance equipped with 2 or 4 twin flat fan nozzles (Novi Fan S.L., Almería, Spain) was connected through a hose 30 m long and 0.017 m in diameter to a wheelbarrow sprayer with a 100-L tank and a membrane pump (M-30, Imovilli Pompe s.r.l., Reggio Emilia, Italy). The crop was green pepper (*Capsicum annuum*, L. 'Palermo') in a twin-row system (two rows planted close together; see Fig. 2) 2 m apart with 0.4 m between plants (1.6 plants m^{-2}). The different trials were performed over a period of 2 years (two crop cycles). In the first year the effect of pressure and in the second year the influence of the application rate were investigated.

The assays were performed in the southern part of the greenhouse. For both studies, i.e. the influence of application pressure and volume, two tests were made: one in the early-growth stage (test 1) at 158 and 163 days after transplanting for pressure and application rate assessments, respectively, and another at full crop development (test 2) at 332 and 335 days after transplanting for pressure and volume application rate, respectively. Table 1 shows the characteristics of the crop during each of the trials. Leaf-area index (LAI) was measured from 6 plants taken at random in the greenhouse. The plants were completely stripped of their leaves and an electronic planimeter (WinDias, Delta-T Devices Ltd. Cambridge) was used to measure the surface area of each leaf blade. The test area was divided into 3 experimental plots (3 blocks), each made up of 6 crop rows (Fig. 1). Of these, in an alternating sequence, 3 rows were used for test 1 and the other 3 for test 2. This system reduced the risk of contamination between neighbouring applications. On each of the rows selected in each block, a random working condition was tested (one pressure for year 1 and one application rate for year 2). The sampling was conducted on a pair of plants assigned at random in each row of the test, dividing the plant canopy into 12 zones (Fig. 2), 3 heights (H1, H2, H3) and 4 depths (P1, P2, P3, P4). In each zone, a leaf was tagged with filter papers 0.03 × 0.08 m^2 (Filter-Lab Ref. 1238, Filtros Anoia, S.A., Barcelona, Spain), one on the upper side and the other on the underside of the blade. This methodology has been used previously in many studies for pesticide sprayer assessment (Nuyttens et al., 2004b; Sánchez-Hermosilla et al., 2011, 2012, 2013; Llop et al., 2015a). Coinciding with the 4 depths, 4 filter papers were also placed on the ground under the plants in order to quantify spray losses (Fig. 2). Thus, for each application, 84 samples were taken: (12 zones x 2 positions + 4 ground samples) x 3 replicates.

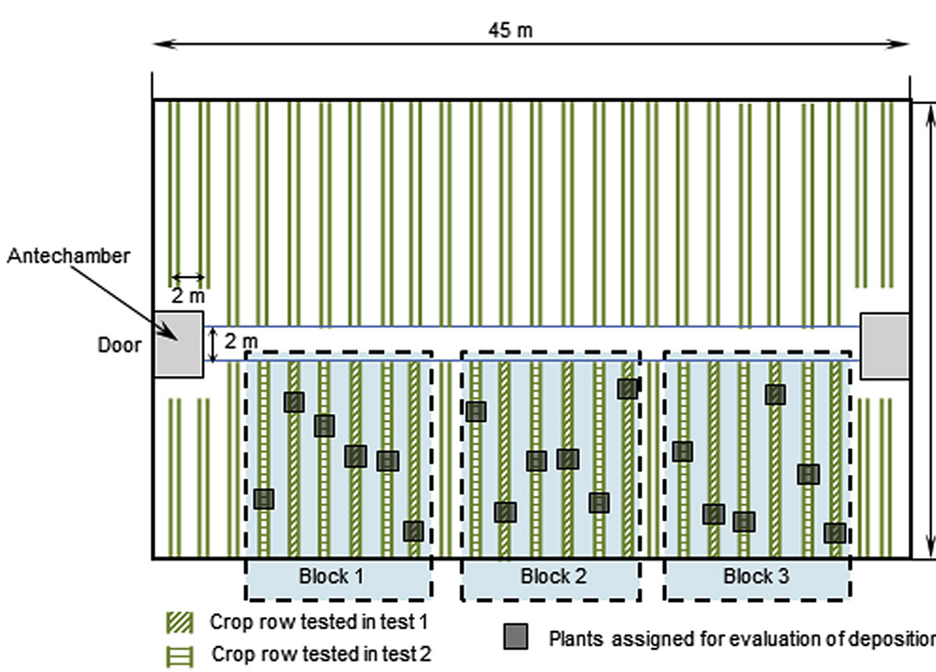

Fig. 1. Ground plan of the greenhouse indicating the sampling blocks of the experimental plants.