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Effect of spray drift reduction techniques on pests and predatory mites in orchards and vineyards

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A B S T R A C T

Spray drift of pesticides has a negative impact on aquatic ecosystems and the environment, including damage to non-target organisms. Particularly, the drift of some insecticides can have detrimental effects on beneficial arthropods such as predatory mites. According to a recent EU Directive, the reduction of spray drift is required for a sustainable use of pesticides, yet without reduction of efficacy against pests. In this framework, eight field trials were conducted from 2012 to 2014 in two typical growing areas of Verona district (Northern Italy), four on apple orchards and four on vineyards. The aim of these trials was to evaluate, for two spray drift reduction techniques: 1) the spatial patterns of in-field droplets, 2) the efficacy against key pests on apple and grape (*Cydia pomonella* L. and *Lobesia botrana* Denis & Schiffermüller respectively), 3) the side effects on predatory mite populations. Four insecticides: chlorpyrifos, chlorpyrifos-methyl, methoxyfenozide and spinetoram, were applied with three different spraying techniques: high-drift nozzles (Albuz, ATR 80 yellow), low-drift nozzles (Albuz, TVI 80015 green), and high-drift nozzles with an anti-drift adjuvant (rapeseed oil). Results showed that the two spray drift reduction techniques effectively increased droplets amounts next to sprayer, reducing potential drift on both apple orchards and vineyards and were generally as effective as standard nozzles without additional side effects on beneficial arthropods. Results suggest that the use of spray drift reduction techniques such as low-drift nozzles and anti-drift adjuvants can be effective in managing key pests and also in decreasing the environmental impact of using insecticides.

Contents

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1. Introduction

In perennial crop systems, pesticide spray drift is a major potential pollution pathway and is considered a serious risk for the environment. According to the ISO standard (ISO, 2005), spray drift (hereinafter: drift) is defined as the quantity of plant protection product that is carried out of the sprayed (treated) area by the action of air currents during the application process. Recent studies show that drift poses a risk to surface water (Boesten et al., 2007; Dabrowski et al., 2005; Verro et al., 2009) and there is increasing concern about potential pesticide exposure to neighbouring property, bystanders and passers-by, particularly in fragmented landscapes where farms are surrounded by residential housing, as frequently occurs in Southern Europe (Otto et al., 2015). Drift of pesticides may damage beneficial arthropods (Druart et al., 2011; Otto et al., 2013). Evaluations of the effects of pesticides on beneficial arthropods are used in regulatory environmental risk assessments. In particular, predatory mites belonging to the Phytoseiidae family (hereinafter: phytoseiids) represent an important component of Integrated Pest Management programmes worldwide (Helle and Sabelis, 1985) and they have been widely considered as non-target beneficials in pesticide effect evaluations (e.g. Candolfi et al., 1999; Hardman et al., 2007; Tirello et al., 2013; Sterk et al., 1999).

Indeed, application of insecticides is still necessary in European orchards and vineyards for the control of various pests. Northern Italian orchards and vineyards are damaged by numerous arthropod pests, mainly codling moth (*Cydia pomonella* L. (Lepidoptera: Tortricidae)) on apple and grapevine moth (*Lobesia botrana* Denis & Schiffermüller (Lepidoptera: Tortricidae)) on grape, as well as leafhoppers, thrips, scales and mites (Caffi et al., 2016; Pertot et al., 2016). Losses due to codling moth can reach 80% and are caused by larvae that penetrate into fruits, damaging them and causing them to fall (Barnes, 1991). In Italy, the pest has two or three generations per year depending on cultivation area and climatic conditions. Codling moth infestations are often managed with 1–2 applications of insecticides against larvae of each generation.

The grapevine moth completes from two to four generations per year depending on climate and annual meteorological conditions (Gilioli et al., 2016; Pavan et al., 2013). The larvae of the second generation onwards cause yield losses and favour the spread of bunch rots. Chemical control targets eggs and larvae of the second generation using various insecticides. Among these, organophosphates and pyrethroids are still used because of their efficacy and low cost (Coscollá, 1997). A recent European Directive (European Directive EC 128, 2009) established guidelines for a sustainable use of pesticides in order to prevent or reduce environmental risk, including damage to non-target organisms and aquatic contamination, and recommended the adoption of mitigation measures for drift.

Since the drift is closely related to spray droplet size (Miller and Tuck, 2005; Taylor et al., 2004; Stainier et al., 2006), the most common recommendation for reducing drift is to use coarser droplets with a smaller fraction of fine droplets, mainly using air-induction nozzles (hereinafter: low-drift nozzles) or oil-based anti-drift adjuvants (FOCUS, 2007; Koch et al., 2001; Koch, 2003; SDRT, 2012; Van de Zande et al., 2007; Wenneker et al., 2005). These measures are relatively simple and cheap, and the use of low-drift nozzles in fruit production has increased in many countries in Europe, in particular in Belgium, France, Germany and The Netherlands.

While coarser droplets can significantly reduce drift, they can also reduce spray coverage on the canopy compared to fine droplets, theoretically reducing efficacy against pests. The results of studies on this topic are contradictory. Several European studies on pesticide efficacy in apple orchards showed that there was no significant differences between coarse or conventional fine droplets on *C. pomonella*, aphids (*Dysaphis plantaginea* Pass. and *Eriosoma lanigerum* (Hausmann)), mites (*Aculus schlechtendali* (Nalepa) and *Panonychus ulmi* (Koch)) and apple blossom weevil *Anthonomus pomorum* L. (Friessleben, 2003; Jaeken et al., 2003; Knewitz et al., 2002; Koch et al., 2001; Loquet et al., 2009). However, other studies (Lešnik et al., 2005) showed that insecticide efficacy against codling moth can be significantly reduced by using low-drift nozzles because the coarse droplets do not cover the canopy regularly, and uniform coverage has long been considered necessary for good efficacy of contact pesticides (Matthews, 1977; Munthali, 1984).

According to ISO (2005), there are two sources of drift: primary drift (droplets drift or spray drift, hereafter: droplets drift) and secondary drift (vapour drift or any other form of drift occurring after droplets deposition). Drift of droplets occurs during the treatment, when part of the droplets generated by the sprayer remains inside the field and part leave it as drift. In this study on droplets drift, the in-field droplets pattern was evaluated and related with potential off-field drift: the greater the number of droplets on, or next to, the treated row is, the lower the potential of off-field drift is, thus leading to improved crop protection. The aim of this study was to evaluate whether the use of drift reduction techniques can reduce potential off-field drift while also maintaining the standard efficacy against key pests (*C. pomonella* on apples and *L. botrana* on grapes) and without increasing risks for predatory mite populations.

2. Materials and methods

2.1. Site information and experimental design

The experiments were conducted from 2012 to 2014 in two apple orchards and three vineyards located in Veneto Region (north-eastern Italy). There was a total of eight field trials in five sites (Table 1). Plots were arranged in a randomised block design,