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Effect of Angle of Sprayer Deflector on Spray Distribution in Dwarf Apple Trees

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Abstract: The objective of the study was to determine the influence of the air jet direction by the deflector on the sprayer in canopy spray deposit and off-target loss in dwarf apple trees (Granny smith and Galaxy Gala). They were compared with three deflector angle (0-20-40°). The treatments were carried out in dwarf orchard. The sprayer with the air spouts set 20° upwards produced in orchards higher in canopy deposits and lower off-target loss than did 40°. Further rising of the air spouts and by that directing the air jets 40° upwards increased the spray loss and risk of air bone drift with worse deposits of spray.

Key words: Spray, drift, deflector, air-assisted, distribution

INTRODUCTION

The direction and the outlet shape of the deflectors of the air assisted sprayer are important to direct the air. Recently using shape of the deflectors can be cylindrical, angled or mixed flow. The outlet shape of the deflectors is important for directed air to reduce air velocity losses on the deflectors, to catch deposits on leaves and to apply optimum distribution (Zeren and Bayat, 1995).

The axial fans have been most commonly used in air assisted sprayers, because of their simplicity and low costs. They generate a large radial spray plume which is poorly target matched discharged systems results in more precise application, more uniform spray distribution and less off-target loss (Derksen, 1993; Doruchowski *et al*., 1996a). Several target oriented techniques, such as cross flow, directed air jet and tunnel sprayers with horizontal or adjustable air discharge systems have been developed. The cross-flow sprayers, when compared to the conventional ones, cause lower spray loss but horizontal air jet usually results in higher deposits on upper leaf surfaces than the lower ones (Hollownicki *et al*., 1996). Wiedenhoff (1991) recommends angling the air jet 12° upwards to optimize the spray deposition on the leaves.

In recent years, the spray techniques for field trees in nursery production have been studied (Krause *et al*., 2004; Zhu *et al*., 2005). The spray displacement is strongly influenced by air jet velocity and volume. Derksen and Gray (1995) reported in canopy deposits delivered at higher air velocities may be greater, but at the same time spray emission to the air may also increase (Doruchowski *et al*., 1996a). Doruchowski *et al*. (1996b) have shown that the higher velocities of air usually increase the spray loss recorded behind the trees and reduce the loss measured on the soil under the trees.

The aim of this study was to determine the influence of the air jet direction by the deflector on the sprayer in canopy spray deposit and off-target loss in dwarf apple trees.

MATERIALS AND METHODS

Treatments were carried out in dwarf orchards in Marmara region-Turkey in 2006. There were two types of apple orchards (Galaxy Gala and Granny Smith; dwarf orchard; tree spacing 3.6×0.8 m; tree height and width 1.8×1 m).

Treatments were done by a rear mounted air assisted sprayer (Taral company, Turbo 400-A). It had 400 L capacity of tank, TAR 50 diaphragm pump (50 L ha^{-1}, 0-40 kg cm^{-2}), 760 mm diameter axial fan, 720 mm diameter propeller was rotated by 1950 min^{-1}. Fan air velocity and flow were 30 m h^{-1} and 2400 m^3 h^{-1}, respectively.

The two deflectors were fixed to the upper part of the fan's frame. The air direction was arranged by changing angle of deflectors. For this study they were fixed different angle; 0-20-40°. The sprayer had 8 nozzles (hollow cone) arranged circular on the fan. At all treatments 400 L ha^{-1} spray volume were used.

The sprayer was connected to a 46 kW tractor and measured pressure, 12 bars, was constant in all the treatment. The spray flux and the spray coverage were evaluated on one side of the sprayer, always in the same sampling position in the treated rows. During the test, three repetitions were made with the sprayer at 6 km h^{-1} sprayer speed.

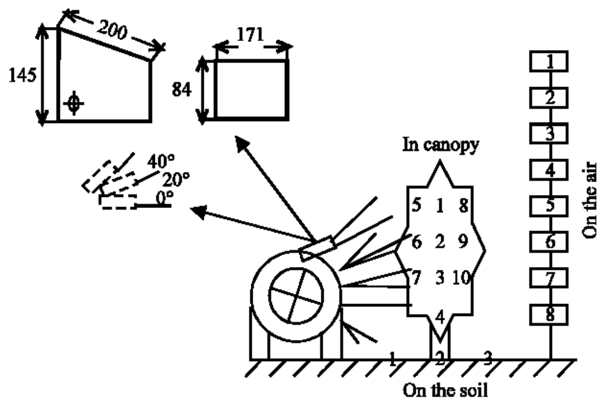

Fig. 1: Layout of filter papers for evaluation of in canopy spray deposit and off-target spray loss

In this study Lutron AM 4202 anemometer for wind velocity and Testo 605-h1 for humidity and temperature were used.

Filters paper (Schleicher and Schuell, 589^2 white ribbon, ashless, 125 mm diameter) was used to evaluate vertical distribution of spray deposits in canopy and off target loss. They were attached on leaf in canopy (center of the tree) to evaluate penetration effectiveness of the spray and on the ground and a wooden bar to determine off target loss. They were located according to layout shown in Fig. 1. The wooden bar which has 4 m height placed 1.5 m near the tree. Filter papers on the wooden bar were attached from top to down by 0.5 m.

Brilliant sulphaflavine at the concentration 0.02% was used as a tracer. Jenway 6200 Fluorimeter was used to measured spray deposit.

Data was analyzed by ANOVA followed by Duncan's Multiple Range Test to separate mean values of deposit and spray loss for treatments. Coefficient Variation (CV%) for spray deposit was calculated. The spray deposit data were converted to a percentage of volume applied to show the total spray loss.

RESULTS

Satisfactory control of diseases and pests, also those feeding on the undersides of leaves is achieved when the spray is deposited uniformly on both their sides. The air assisted sprayers used in fruit growing cause 3-6 times higher deposits at the upper side than underside of leaves (Table 1). To improve this ratio the spray techniques are needed that will apply sufficient spray on the lower leaf surfaces (Hollownicki *et al*., 1998). In this study total and underside deposit is shown in the tables.

The deflectors up to 40°, no differences were observed in deposition in the leaf surfaces. In this case

Table 1: Spray deposits (mg cm^{-2}) on the lower leaf surfaces and in total (upper+lower) within the dwarf apple canopy for treatments with different deflector angles

Angles of deflector	Mean		Center of the tree		CV (%)
	Lower	Total	Lower	Total	
40°	59.1a	183.2bc	46.0a	85.0ab	95.4
20°	62.0a	281.1c	45.9a	204.0c	98.0
0°	112.3b	176.0bc	49.1a	101.6ab	119.1

Means in columns followed by the same letter(s) do not differ significantly at p>0.05

Table 2: Spray loss (mg cm^{-2}) to the soil and to the air (upper and lower part of the frame) for treatments with different deflector angles

Angles of deflector	Soil	Vertical wooden bar behind the trees			% of volume applied
		0-2 m	2-4 m	Average	
0°	56.1bc	25.0b	49.9b	41.1b	71.3
20°	51.7b	22.4b	25.7a	21.0a	59.4
40°	22.0a	28.0b	72.1b	49.3b	51.0

Means in columns followed by the same letter(s) do not differ significantly at p>0.05

very short distance from the fan outlet to the target caused that the canopy absorbed the major part of the spray

The sprayer with deflectors directed 20° upwards caused the highest total deposit in dwarf apple orchard. It might be because at this air jet setting, when the lower air deflectors angled upwards was close to the ground. The passage distance of spray through the tree canopy was relatively long the droplet catch efficiency was optimal.

Raising the deflectors directed 0° significantly increased deposit on lower leaf surfaces in dwarf orchard. However such a setting of deflectors decreased total deposit in average and in the center of the trees. Excessive angling of the deflectors in directed air-jet sprayer increases CV% and may be disadvantageous when spraying orchards (Hollownicki *et al*., 1998).

The change of the angle of deflectors from 20 to 40° in sprayer during applications in dwarf orchard caused increase in deposit variation where some decrease of variation was observed.

The spray loss to the soil under the trees was approximately over two times higher in dwarf orchard than the loss to the air, recorded on the wooden bar placed right behind the sprayed trees, because of higher droplet catch efficiency (Table 2). Since there are denser foliage and bigger width of the canopies the air jet velocity slowed down sooner and bigger droplets fell out of the stream to reach the ground and increase the soil contamination. Rising the deflectors from 20-40° during spraying significantly decreased the spray loss to the soil. At same time it increased the loss to air, resulting in higher total spray loss expressed as a percentage of volume applied. It also relocated the loss to the upper part of the frame which may cause higher risk of air bone drift.

The highest loss in the dwarf orchard was produced by the 0° angle of deflector. The loss to the soil caused by this sprayer was not significantly than by the 20° angle of deflector. The total loss was not significantly different than by the 40° angle of deflector.

DISCUSSION

We reported as Hollownicki *et al.* (1998) that the high volume directed air jet system sprayer with the air spouts set 20° upwards produced in modern orchards higher in canopy deposits and lower off target loss than did the conventional and cross flow sprayers. Further rising the air spouts and by that directing the air jets 40° upwards increased the spray loss and risk of airborne drift with no better or worse deposits of spray. The off-target losses (ground deposit plus spray drift) of 25.7% less than those observed in apples (Salyani *et al.*, 2007). Spraying the edge row of dwarf apple trees, Fox *et al.* (1990) showed that ground deposits of drifted spray decrease greatly.

Wiedenhoff (1991) differ with angling the air jet 12° upwards to optimize the spray deposition on the leaves.

CONCLUSIONS

Spray losses was same ratio on the dwarf apple trees with narrow row for each angles. So effects of deflector were not significantly.

Rising the deflectors directed 20° deposit distribution on upper leaf surfaces in dwarf orchard were significantly good. Drift was determined little. But raising the deflectors directed 40° drift risk was increased. Drift was like flowing to ground and into air

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