

Field Testing of a Prototype Recycling Sprayer in a Vineyard: Spray Distribution and Loss

C. Baldoin, C. De Zanche and D. Bondesan

Dept. of Land and Agro-Forestry Systems – University of Padua – Agripolis, viale dell'Università – 35020 Legnaro Italy

cristiano.baldoin@unipd.it

ABSTRACT

A prototype recycling sprayer was tested in a vineyard with the aim to analyze the distribution of spray in the canopy and the off target dispersion of the spray. The sprayer was developed in co-operation with a manufacturer based on a commercial wrap-around sprayer with centrifugal fan and hydraulic nozzles. The nozzles are fitted inside air spouts placed along vertical air ducts, located so that two converging air jets reach each other at the canopy. Two vertical panels (120 x 200 cm) were installed on the same folding arms on which the air ducts are placed, and a horizontal panel was placed which covers the canopy. Excess liquid is collected on the lower side of the panels and sucked back into the tank by a Venturi hydro injector. Part of the air streams delivered by the fan were diverted to additional air ducts in order to create a vertical and a horizontal air curtain on the rear and lower edges of the tunnel. The prototype, not yet ready for being put on the market but functionally completed, was submitted to a field test with several sets of nozzles to verify the capability of the machine to reduce drift and to save active ingredient during the spray application. The recycling device confirmed its efficiency with a saving of about 32% of active ingredients at the end of the treatments.

Keywords: Tunnel sprayers, spray deposition, spray drift, Italy

1. INTRODUCTION

The increasing public concern about environmental pollution which can be observed in the recent years has brought under the spotlight the problem of pesticide target loss during spray application to agricultural crops. In fact, the results of research carried out in recent years point out that, also when modern sprayers with directed jet and tangential airflow are in use, the maximum amount of canopy spray recovery almost never exceeds 60% of the total applied spray dose.

This result, even though it represents a remarkable improvement with respect to the traditional air blast sprayers which are able to place in the foliage only 15-35% of the total distributed liquid, unfortunately does not show further potential of advancement.

Consequently, taking into consideration the low efficiency of common spraying techniques, drift reducing methods have become necessary in order to maximise the fungicide deposition in the canopy. During recent years a number of devices, such as air conveying devices and antidrift nozzles were proposed and tested (Baldoin et al, 2003, 2004; Heinkel et al, 2000; Knewitz et al, 2002), together with electronic sensors to adjust the spray to the crop (Salyani and Pai, 2008, Balsari and Marucco, 2008). In this view recycling sprayers appear to be very promising (Planas

et al, 2002; Baldoin et al, 2005a, 2005b, Wenneker and Van de Zande, 2008) because they are capable of recovering part of the active ingredient thus reducing the real applied dose.

2. METHODS

During a previous research an experimental recycling sprayer was built up based on a commercial wrap-around unit Eurotech “Rafal”. The machine, modified by the manufacturer itself with the co-operation of Dept. of Land and Agro-forestry Systems of Padua University, was equipped with a centrifugal fan and flexible air ducts; spray atomisation is obtained by hydraulic nozzles, displaced along two vertical air ducts and located so that two converging air jets reach the canopy.

A recycling device was assembled by adding two vertical panels (120 x 200 cm) installed on the same folding arms on which the air ducts are placed, and a horizontal panel was placed which covers the canopy. Excess liquid is collected on the lower side of the panels and sucked back into the tank by a Venturi hydroinjector. Further, part of the air streams delivered by the fan has been diverted to additional air ducts in order to create a vertical and a horizontal air curtain on the rear and lower edges of the panel (fig. 1).

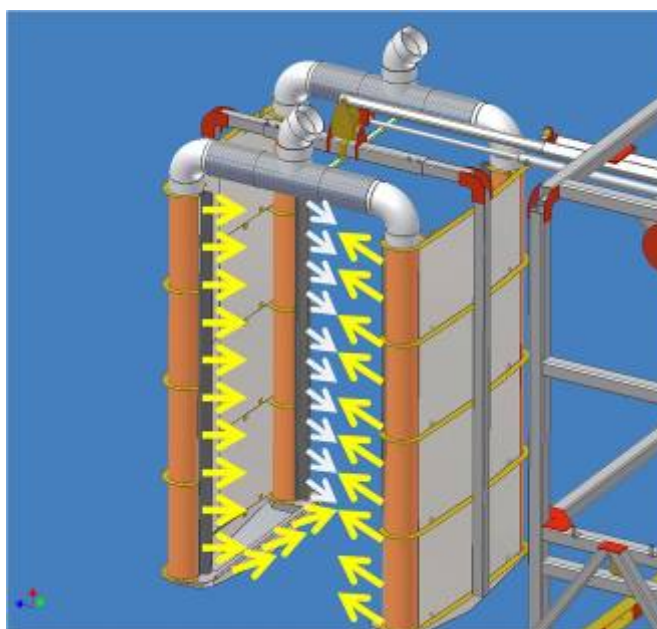


Figure 1. CAD rendered picture of the assembly of the recycling device; the air curtains intended to help to enclose the droplets dispersion are shown by the arrows

The first prototype was tested in a vineyard with the aim of analyzing the distribution of spray in the canopy and the off target dispersion of the spray with encouraging results (Baldoin et al, 2005b).

An improved version of the sprayer, not yet ready for being put on the market but functionally completed (fig. 2), was submitted to a field test to verify the capability of the machine to reduce drift and to save active ingredient during the spray application. This version comprised a lamellae

screen located in the inner side of the recycling panels intended to separate the droplets from the airstream coming from the canopy.



Figure 2. The prototype and the vineyard

For the tests the sprayer was equipped with several sets of nozzles in order to verify the effect of the spray atomization on the functionality of the recycling panels. Six types of nozzles (air-inclusion, flat-fan, twin flat-fan and cone, with and without the air assistance) were tested and compared to the traditional spray application technique; the sprayer was calibrated for a volume of 300 litres/hectare.

The experimental plot was set up as follows:

Tunnel sprayer (300 L/ha, 5.2 km/h; #nozzles/sprayed row side)

1. 3 TwinJet double fan nozzles ISO 110-02 @ 10 bar
2. same as 1, fan disengaged
3. 3 air inclusion nozzles ISO 110-02 @ 10 bar
4. same as 3, fan disengaged
5. 3 flat fan nozzles, ISO 110-02 @ 10 bar
6. 3 hollow cone nozzles, ISO 110-02 @ 10 bar

Air carrier sprayer (500 L/ha, 5.2 km/h)

6 hollow cone ATR 80 Blue nozzles @ 11 bar

The air carrier sprayer was operated at higher volume due to specific needs of the hosting farm.

Spatial distribution of spray was assessed by means of paper strips located in the vineyard according to the layout shown in figure 3.

A trial about biological effectiveness of spray application was also carried out in an espalier trained vineyard, cv Grey Pinot and Merlot; four replications were made with periodical surveys about the progression of the disease.

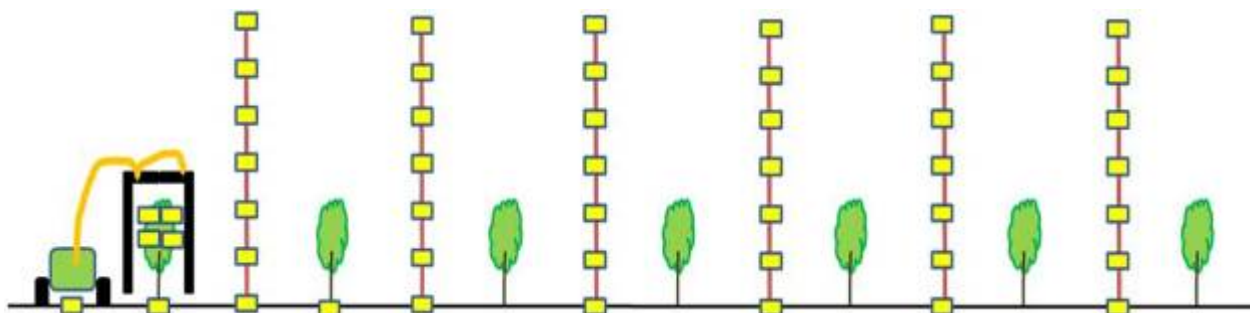


Figure 3. Layout of the location of the collectors

3. RESULTS

3.1 Spray Distribution and Loss

Figures 4 to 10 summarize the amount of spray mixture as retrieved on the collectors. The size of the “bubbles” in the pictures are proportional to the amount of tracer at the given position.

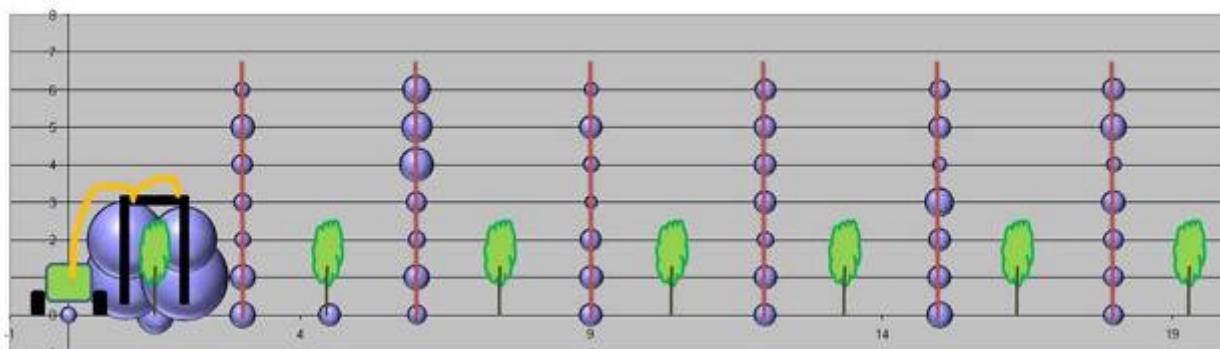


Figure 4. Spray deposition and dispersion using the prototype with TwinJet nozzles (trial 1)

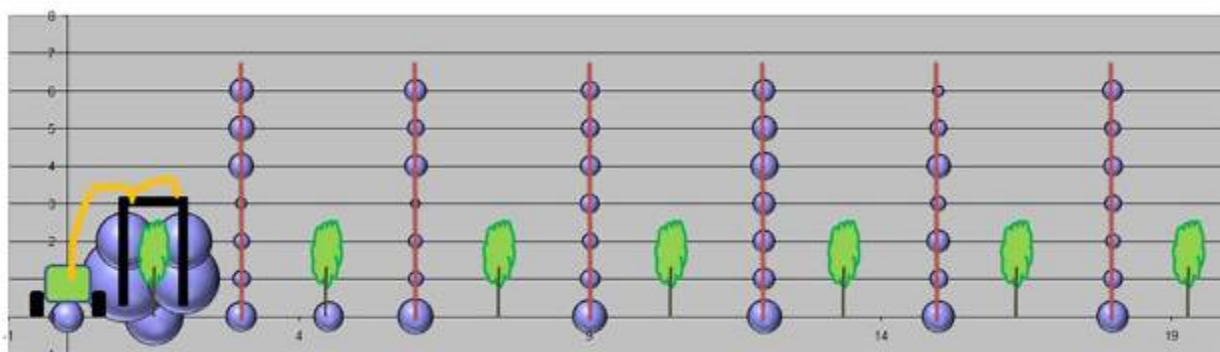


Figure 5. Spray deposition and dispersion using the prototype with TwinJet nozzles without air assistance (trial 2)

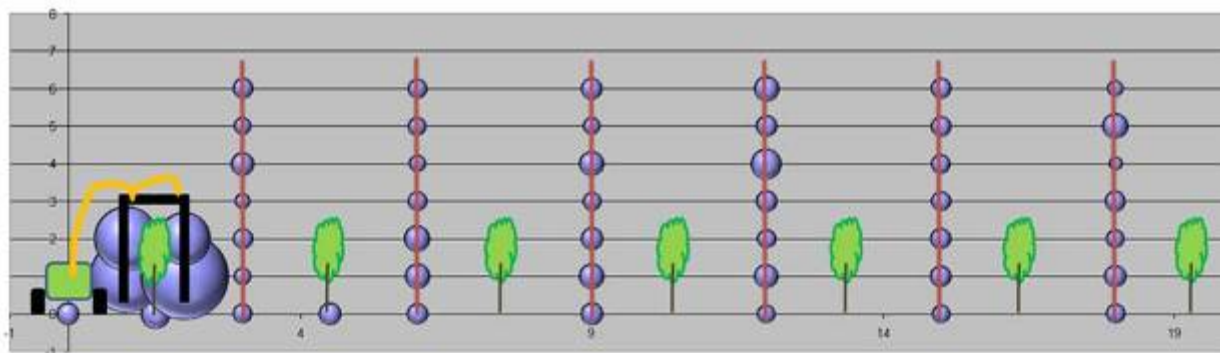


Figure 6. Spray deposition and dispersion using the prototype with air inclusion nozzles (trial 3)

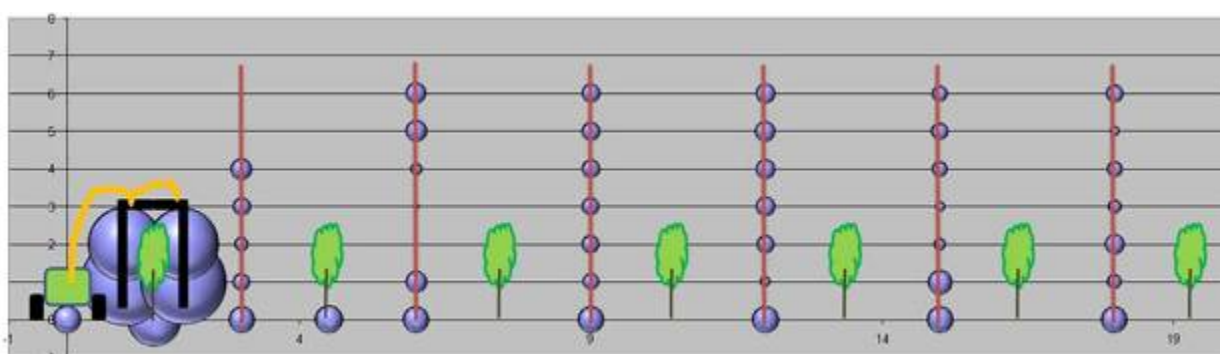


Figure 7. Spray deposition and dispersion using the prototype with air inclusion nozzles without air assistance (trial 4)

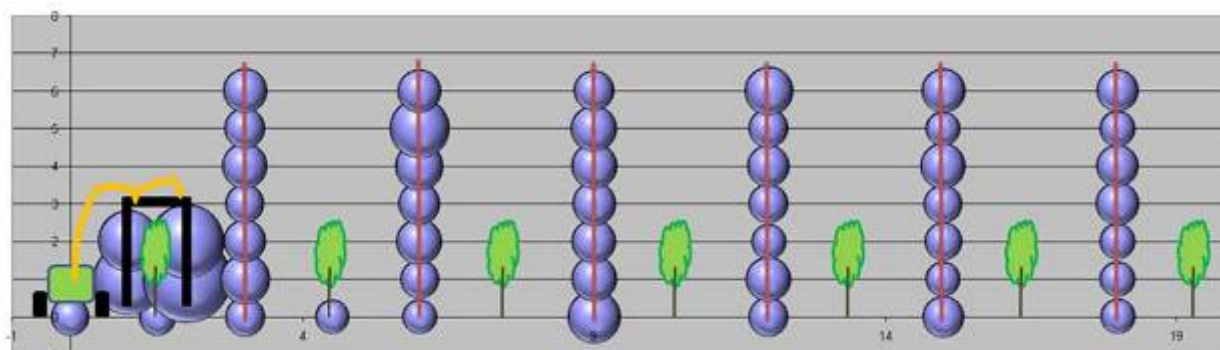


Figure 8. Spray deposition and dispersion using the prototype with flat fan nozzles (trial 5)

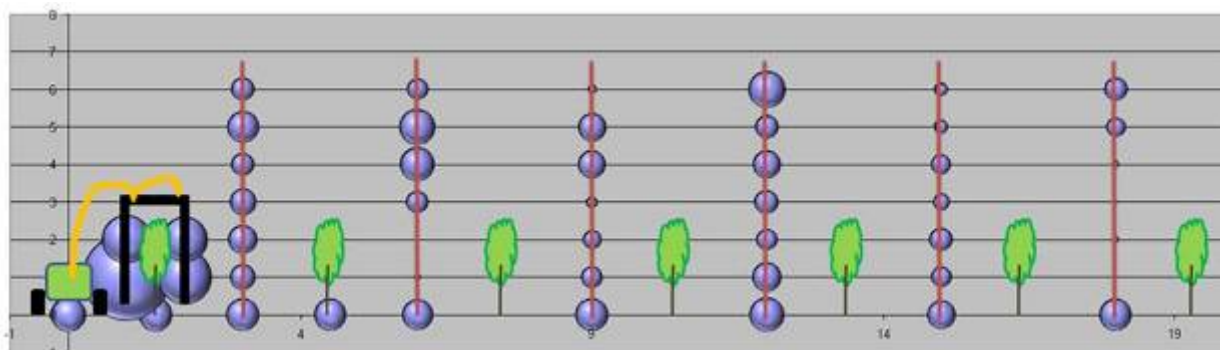


Figure 9. Spray deposition and dispersion using the prototype with hollow cone nozzles (trial 6)

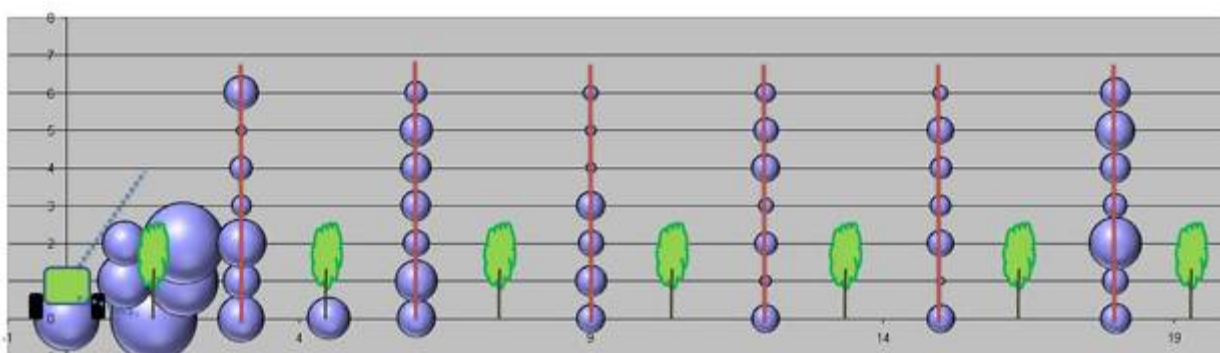


Figure 10. Spray deposition and dispersion using the conventional air assisted sprayer with hollow cone nozzles (trial 7)

Table 1 summarizes the amount of tracer recovered on all of the collectors.

As shown in the graphs, a high amount of ground losses were found with the air carrier sprayer (fig. 10), especially in the treated row and in the travel lane; high amount of spray drift on the 6° row and on top of the first pole (fall out).

Spray deposition in the canopy was highest when air inclusion and twin jet nozzles were in use (see table 1), while flat fan nozzles gave the worst result in terms of foliar deposition and spray drift, maybe due to the too fine atomization which allowed the finest droplets to run away from the rear side of the tunnel.

Further, remarkable differences were found in the effectiveness of the droplet capture process by the recycling panels when using the different sets of nozzles. Spray dispersion appears to be affected by nozzles type (trial 5 vs. trial 1, see figs. 8 and 4), and air assistance (trial 1 vs. trial 2, see figs. 4 and 5).

As regards canopy deposition, in particular, figure 11 shows the profiles of distribution in the canopy of all of the trials. Twin Jet and Air Inclusion nozzles gave the best results either in terms of amount of deposition and of regular shape of the profiles.

Table 1. Total amount of tracer retrieved on the collectors located at the different sample positions (sum of foliar, ground and off-target deposition)

<i>treatment</i>	deposition (ml) (*) and distribution (%)		
	<i>ground</i>	<i>canopy</i>	<i>drift</i>
1 – prototype – TwinJet nozzles	26 <i>11%</i>	123 <i>53%</i>	86 <i>36%</i>
2 – prototype – TwinJet nozzles – no air	58 <i>26%</i>	94 <i>43%</i>	67 <i>31%</i>
3 – prototype – Air Inclusion nozzles	24 <i>10%</i>	115 <i>50%</i>	91 <i>40%</i>
4 – prototype – Air Inclusion nozzles – no air	48 <i>19%</i>	145 <i>59%</i>	54 <i>22%</i>
5 – prototype – flat fan nozzles	26 <i>14%</i>	42 <i>22%</i>	123 <i>64%</i>
6 – prototype – hollow cone nozzles	47 <i>22%</i>	75 <i>36%</i>	87 <i>42%</i>
7 – air carrier sprayer	89 <i>32%</i>	73 <i>26%</i>	119 <i>42%</i>

(*) *total amount of tracer retrieved on the collectors*

3.2 Effectiveness of Spray Applications against Downey Mildew

Since the disease was not particularly virulent an assessment about biological efficacy of the treatments could not be performed, as crop protection was deemed to be only preventive. Anyway, the recycling device confirmed its efficiency with a saving of about 32% of active ingredients at the end of the treatments (see fig. 12).

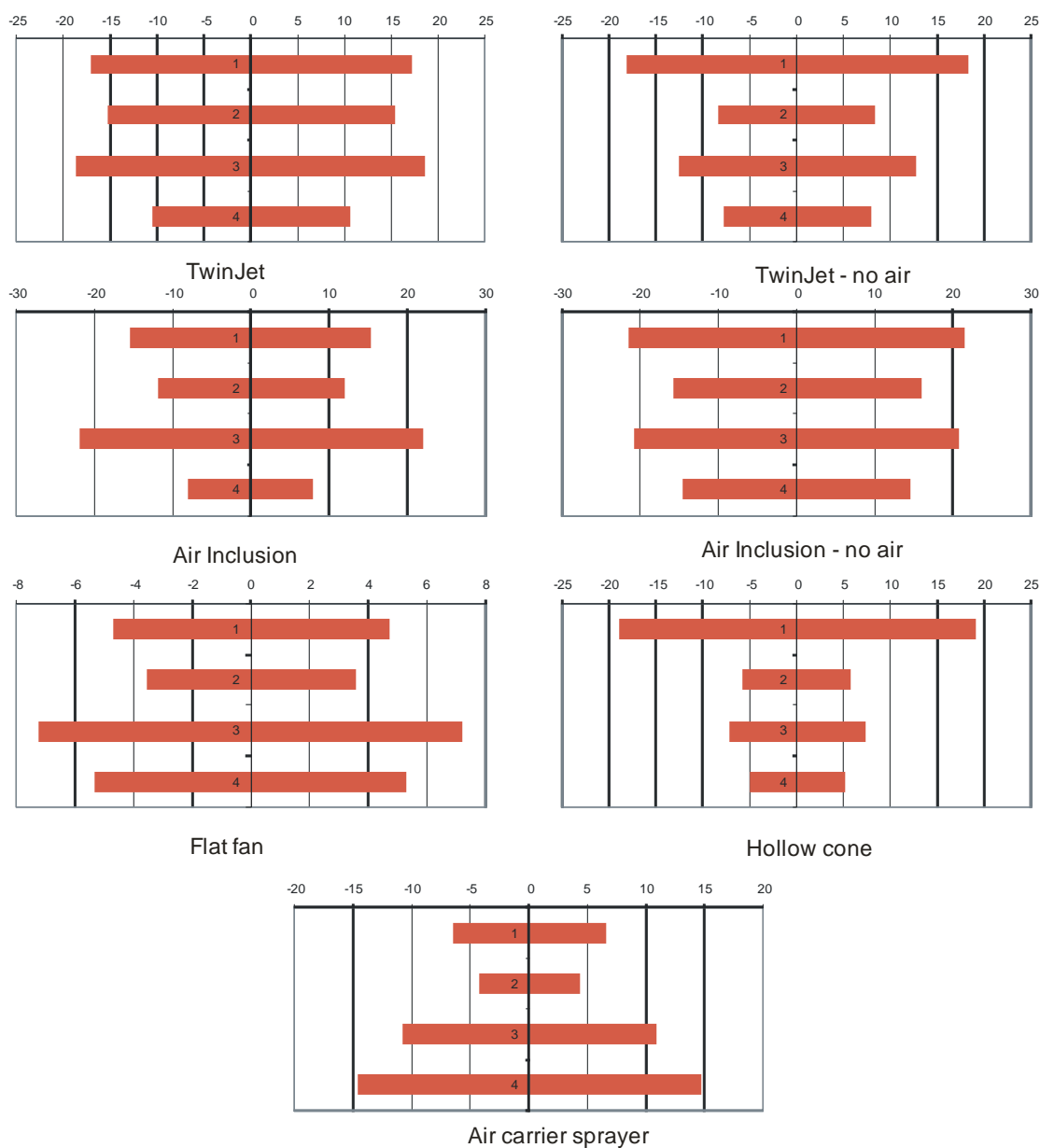


Figure 11. Spray deposition profiles in the canopy; the length of the bars is proportional to the amount of tracer retrieved at the sampling positions

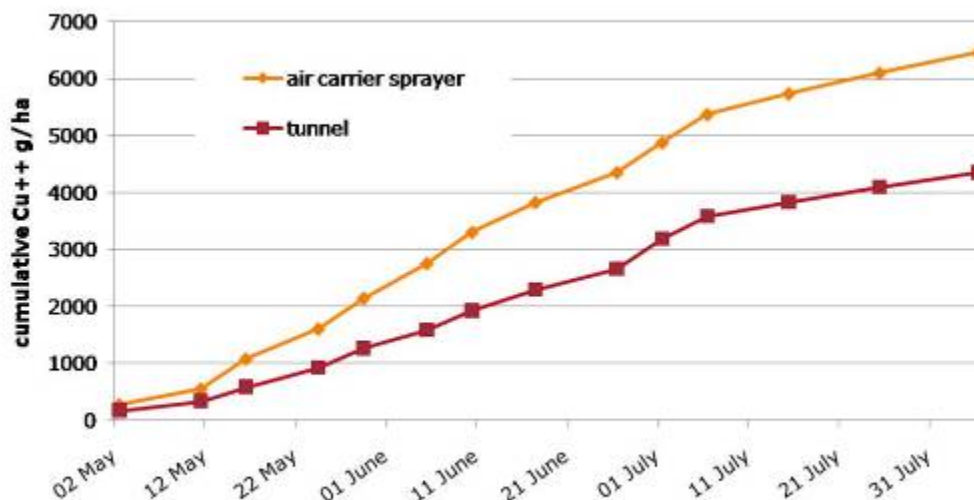


Figure 12. Cumulative amount of copper distributed during the season

4. CONCLUSIONS

Efficiency of recycling in drift reduction and saving of plant protection product were confirmed by the results of the research. Tunnel sprayers should be suitable for use with environment-friendly spraying techniques.

There is a need for further improvement. In particular it is necessary to ensure that the recovered liquid is cleaned before being sent back to the tank, and this requires an accurate design of filtering system.

The second problem, which indeed affects all of the Variable Rate application equipment is that actual volume is not predictable. Therefore it is necessary to investigate the efficiency of a recycling device in order to give the farmer the appropriate instructions about how much mixture to prepare to spray a given area according to the geometry of the crop.

5. ACKNOWLEDGEMENTS

The research was carried out with financial support from the Venetian Region.

The contributions to the work are equally shared among the authors.

6. REFERENCES

- Baldoin C., Beria S., De Zanche C. (2003) Performance of Air Inclusion nozzles on vineyard sprayers. *7th Workshop on Spray Application Techniques in Fruit Growing* Cuneo, 25-27 June 2003, 273-279

- Baldoin C., Beria S., De Zanche C., Sorgato F., Dalla Pace A. (2004) Efficacy of treatments against downy mildew of grapevine with contact fungicides using Air Inclusion nozzles on different sprayers. *Aspects of Applied Biology* 71, *International advances in pesticide application* 2004, (1) 247-254
- Baldoin C., De Zanche C., Sorgato F., Zanardi W. (2005) Performances of a new shielded sprayer on vineyard. *Annual Review of Agricultural Engineering* 2005, (1) 257-265
- Baldoin C., De Zanche C., Sorgato F., Zanardi W., Dalla Pace A. (2005) Biological effectiveness of spray application against downy mildew using a recycling sprayer. *VIII Workshop on Spray Application Techniques In Fruit Growing, Barcelona*
- Balsari P., Marucco P. (2008) The development of a Crop Identification System (CIS) able to adjust the spray application to the target characteristics *Agricultural Engineering International: the CIGR Ejournal*, Manuscript ALNARP 08 002, Vol. X . May, 2008
- Heinkel R, Fried A, Lange E. (2000) The effect of air injector nozzles on crop penetration and biological performance of fruit sprayers. *Aspects of Applied Biology, Pesticide Application*, 5, 301-307
- Knewitz H, Weisser P, Koch H. (2002) Drift-reducing spray application in orchards and biological efficacy of pesticides. *Aspects of Applied Biology, International advances in pesticide application*, 66, 231-236
- Planas S, Solanelles F, Fillat A. (2002) Assessment of recycling tunnel sprayers in mediterranean vineyards and apple orchards. *Journal of Agricultural Engineering Research*, online at <http://www.idealibrary.com>
- Salyani, M, Pai R.D. (2008) On-the-go changing of sprayer airflow based on tree foliage density *The CIGR Ejournal*, Manuscript ALNARP 08 013, Vol. X . May, 2008
- Wenneker M., Zande Van de J. (2008) Drift reduction in orchard spraying using a cross flow sprayer equipped with reflection shields (Wanner) and air injection nozzles. *The CIGR Ejournal*, Manuscript ALNARP 08 014, Vol. X . May, 2008