J. of Ag. Eng. - Riv. di Ing. Agr. (2008), **1**, 41-48

STUDY OF A NEW MODEL OF SPRAYER FOR APPLICATIONS IN "TENDONE" VINEYARDS

Emanuele Cerruto, Giuseppe Emma, Giuseppe Manetto

1. Introduction

According to the Italian Central Statistics Institute [9], Apulia and Sicily totalised in 2004 the 91% of the Italian production of grapes for the fresh market. The most widespread growing system for this crop is the "tendone", where the vegetation grows on a horizontal plane at a height of some 2 m above the ground.

In Sicily the crop requires 15-18 spray applications, with some 350-700 L/ha of mixture. The most widespread sprayer is the "conventional" atomiser, with hydraulic pulverisation, arc-shaped spray boom, axial fan, and turbulence nozzles. This sprayer model presents several limitations when used in spraying tendone vineyards, among which Guarella and Pascuzzi [7, 8] emphasize the difficulties in regulating airflow directions and nozzles orientation. They suggest different spray boom geometries, specifically designed for spraying horizontal surfaces situated above the ground.

So we designed and tested a new model of sprayer, with the spray boom that partially meets the geometry of the vegetation of the vineyard. This paper reports the first results of an experimentation carried out to assess the performances of this prototype. To this aim the foliar deposition was investigated varying forward speed and airflow rate. These are two important parameters, whose correct selection influences the success of a pesticide application, as they deeply affect the environmental losses, the uniformity on the canopy, and the timeliness of intervention.

Forward speed affects the real work capacity of the sprayers and the quality of the deposition. Several Authors (Planas *et al*. [13], Salyani and Withney [15]) obtained that increasing the forward speed, increased also the variability of the deposition into the crop. Pergher [10], working in a hedgerow vineyard, reported that forward speeds up to nearly 2.5 m/s, did not significantly decrease the overall deposition, but higher velocities might reduce spray penetration into the canopy and increase deposit variability. Cerruto [2], working also in a hedgerow vineyard, reported that forward speeds in the range 0.9-2.8 m/s did not significantly influence the mean foliar deposition, but intermediate forward speed (1.4 m/s) gave the best uniformity on the canopy.

As regards airflow rate, the benefits of air assistance for orchard spraying are well-known. The forced air jet transports the droplets throughout the target, moves the foliage, and allows their penetration and depositing on the plant surface, including the undersides of leaves. Though, the choice of the correct amount of airflow rate is still investigated [1], as it depends on several variables: cultivation, phenological stage, training system, tree size, shape and foliage density, distance between rows, forward speed, and type of fan. Several Authors (Pezzi and Rondelli [12], Cross et *al*. [5], Salyani and Farooq [16]) reported that increasing the airflow rate improved the uniformity of the spray coverage, but led to higher losses to the ground and higher spray drift. Pergher [10, 11] showed that, working in a hedgerow vineyard with a sprayer fitted with axial fan, a decrease in the airflow rate from 10.6 m^3/s to 6.3 m^3/s, or from 8.6 m^3/s to 7.0 m^3/s, or from 7.1 m^3/s to 4.7 m^3/s, always resulted in an increase in the average foliar deposition. Cerruto [2, 3] obtained similar results operating reduction in airflow rate from 7.5 m^3/s to 3.9 m^3/s.

With this study we continue research on the effects of these two parameters on foliar deposition, trying a prototype of sprayer fitted with radial fan and equipped with spaying modules which direct the airstream towards the target.

Paper received 18.05.2007; accepted 07.03.2008

Emanuele Cerruto, Associate Professor (ecerruto@unict.it), Giuseppe Emma, Phd (gemma@unict.it), Giuseppe Manetto, Researcher (gmanetto@unict.it), Dipartimento di Ingegneria Agraria, University of Catania, Italy.

Research developed within the 2003 MIUR project *Deposit optimisation in treatments in "Tendone" vineyards for the fresh market,* year 2003, prot. 2003072758_005".

The Authors equally contributed to the present study.

2. Materials and methods

2.1 *Planning of the experimental tests*

Experimental tests were carried out within the period of two years, so arranged:

– First year (2004): comparison between the prototype in two configurations and a conventional air assisted sprayer (the farm sprayer);
– Second year (2005): study of the prototype, in one configuration, varying airflow rate and forward speed.

In both years, the experimental tests were replicated in two phenological stages, so to consider the effect of a different foliar development.

2.2 *The sprayers*

The farm sprayer used in 2004 was a conventional one (Figure 1), with a 600 L main tank, hydraulic pulverisation, and arc-shaped spray boom equipped with 16 brown "Albuz ATR" nozzles (orifice diameter = 1.0 mm). The 0.8 m axial fan was powered by the power take off (pto) by means of a gear box with two gear ratios (3.5:1 and 4.4:1). The maximum airflow rate, according to the manufacturer, was some 7.30 m^3/s.

The prototype derived from the Nobili Company "Oktopus Mini 40-600 OT" model by modifying the spray boom geometry. It maintained the 600 L main tank, the hydraulic pulverisation system, and the two fan gear ratios (3.7:1 and 5.0:1). The radial fan diameter was 400 mm in 2004 and 430 mm in 2005. Being a prototype, the airflow rate was measured by the Authors. The measurement was however carried out only in 2005, when the effects of the airflow rate on foliar deposition were investigated.

The spray boom consisted of 7 adjustable spraying modules equipped with "Albuz ATR" nozzles and arranged on a horizontal bar at a height ranging from 0.95 to 1.35 m above the ground. The bar was made of three segments: the central one, fixed, 0.85 m long, carrying three modules, and two lateral, rotating, each with two modules. When the lateral segments are closed (Figure 2), the in field manoeuvrability improves, while opening them (Figure 3), the spraying modules approach the vegetation. Position and direction of the spraying modules were settled according to the canopy features. This configuration was presumptively considered more adapt to the tendone geometry, so the research was mainly focused on it.

Fig. 1 - Farm sprayer during preliminary tests.

Fig. 2 - First configuration of the sprayer prototype.

Fig. 3 - Second configuration of the sprayer prototype.

2.3 *The vineyards*

The tests were carried out in two tendone vineyards, one for each year, located in two farms of the Mazzarrone territory (province of Catania). In this area the production of grapes for the fresh market is very widespread. Both vineyards had a square layout (3.0×3.0 m in 2004 and 2.9×2.9 m in 2005) and a supporting structure of the vegetation at a height of about 2 m in the first year and 1.8 m in the second year. This structure was supported with reinforced concrete pillars located just next to the trees. It was made with crossed iron wire so to obtain square meshes of about 0.5 m. So among the trees it was possible to identify, with respect to the forward movement of the sprayer, six sectors (from S1 to S6) in crosswise direction and six rows (from F1 to F6) in lengthwise direction (Figure 4), used as references for measurements and leaves sampling.

In both vineyards (cultivar "Red Globe") each vine had 3-4 fruit leaders with random orientation, so that the vegetation profile was on average uniform at full foliage development. To characterise the vineyards, thickness of the vegetation along vertical direction and Leaf Area Index (LAI) were measured in each phenological stage. The average LAI profiles were adopted as references to adjust position and direction of the spraying modules.

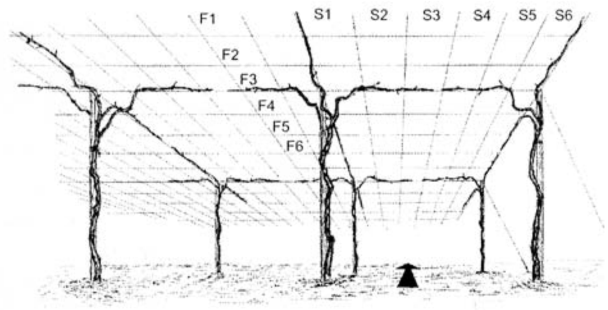

Fig. 4 - Schematic view of the structure of the vineyards.

2.4 *The experimental tests*

According to the objectives of the research, in 2004 an experimental plan was adopted with three sprayer setup: T1 = farm sprayer (Figure 1); T2 = prototype with the bar side segments closed (Figure 2); T3 = prototype with the bar side segments open (Figure 3). The working settings practiced in the farm were adopted for both sprayers: pressure = 1.6 MPa, forward speed = 2.13 m/s, power take off rotation speed = 56 rad/s, and type of nozzles = Albuz ATR (brown (1.0 mm) for the farm sprayer and yellow (1.2 mm) for the prototype, to not reduce the volume rate excessively). These parameters were kept unchanged in both phenological stages: code 75 (Berries pea sized, 21/06/04) and code 79 (Berry touch, 20/07/04) of the BBCH Scale.

In 2005, the experimental tests were carried out using only the prototype in the second configuration (Figure 3), assessing its performances varying airflow rate and forward speed. To this aim a full factorial experimental design was adopted, with two forward speeds and two airflow rates, kept constant in both phenological stages: code 75 (Berries pea sized, 09/06/05) and code 81 (Beginning of ripening, 21/07/05) of the BBCH Scale.

The selected forward speeds were 1.58 m/s (that usually adopted in this second farm), and 1.05 m/s. The two airflow rates (1.81 m^3/s and 2.14 m^3/s) were that obtained acting on the fan gear ratio, keeping constant the power take off speed (54 rad/s). They were extrapolated measuring the air velocity at the output of the spraying modules (Figure 5), using a hot-wire anemometer (VelociCalc TSI mod. 8355). The extrapolation was necessary as higher pto speeds resulted in air velocities out of the measuring range of the instrument. Based on these results and taking into account the lower fan diameter, the airflow rate in 2004 was estimated at 1.78 m^3/s.

To maintain comparable volume rates with both forward speeds at the same pressure (1.5 MPa), Albuz ATR nozzles with different colour were used: yellow (1.2 mm) at 1.05 m/s and orange (1.5 mm) at 1.58 m/s. The corresponding volume rates were 435 and 400 L/ha.

A summary of the whole experimental plan is reported in Table 1. For each year and stage it was arranged according to a randomised block design with three replicates. Each replicate consisted in just one spray pass, delivering a water solution with 2% of food dye Poinceau Red as a tracer and 0.05% of a surfactant.

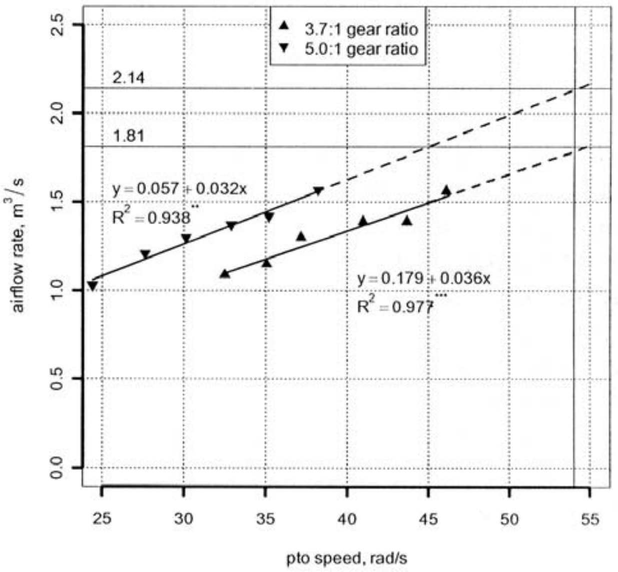

Fig. 5 - Airflow rate of the prototype versus power take off speed.

Sprayer setup	forward speed, m/s	nozzles diameter, mm	airflow rate, m^3/s	volume rate, L/ha
First year (T1=farm sprayer; T2, T3=prototype)				
T1 (Fig. 1)	v = 2.13	1.0	7.30	350
T2 (Fig. 2)	v = 2.13	1.2	1.78	240
T3 (Fig. 3)	v = 2.13	1.2	1.78	240
Second year (only the prototype, Fig. 3 configuration)				
A_1v_1	v_1 = 1.05	1.2	A_1 = 1.81	435
A_1v_2	v_2 = 1.58	1.5	A_1 = 1.81	400
A_2v_1	v_1 = 1.05	1.2	A_2 = 2.14	435
A_2v_2	v_2 = 1.58	1.5	A_2 = 2.14	400

TABLE 1 - Summary of the experimental tests.

2.5 *Leaves sampling and data analysis*

After spray application, a number of leaves were picked on the sample trees (96 leaves/tree, totalising 864 leaves/stage in 2004, and 48 leaves/tree, totalising 576 leaves/stage in 2005). Additionally, a number of untreated leaves (96 for each stage in 2004 and 144 in 2005) were picked in order to assess the background deposit.

With reference to the supporting structure of the vegetation, the sampling area for each sample tree was that depicted in Figure 6. It was subdivided, with respect to the sprayer direction, in two longitudinal rows (R1 and R2), six transversal sectors (from S1 to S6), and two layers (lower = under the supporting structure, and upper = over the supporting structure).

Each sampled leaf was placed in a plastic bag, suitably labelled according to the sprayer setup, the replicate, and the location of the sampling area, and then carried in laboratory, where the unitary foliar deposition was measured by means of a spectrophotometric technique (spectrophotometer Jenway model, Jenway Ltd), according to:

$$d' = \frac{A}{A_m} \frac{10^3 \cdot w}{2 \cdot S} \quad [\mu L / cm^2] \tag{1}$$

where:

- w [mL]: amount of water used for wash each leaf;
- A: absorbance of the washing solution;
- A_m: absorbance of the mixture delivered in field;
- S [cm^2]: leaf surface, measured by means of an image analysis system made up of a digital videocamera (Pixera with 1.2 Mpixel, Pixera Corporation) and a measuring software (Image Pro Plus, Media Cybernetics).

After a correction to take into account the background deposit d_b measured on the untreated leaves:

$$d = d' - d_b \tag{2}$$

all deposits were normalised to a common volume rate V_N, so to account for the differences in the spray volume rates:

$$d_n = \frac{V_N}{V_d} d \tag{3}$$

where V_d is the delivered volume rate. V_N was arbitrarily fixed equal to 350 L/ha, approximately the average value of the delivered volume rates in all the trials.

The normalised unitary deposits d_n were statistically analysed applying the analysis of variance (ANOVA), separately for each year. Data in both years were transformed according to a power equation:

$$d_{nt} = d_n^{\alpha} \tag{4}$$

in order to achieve normal distribution, assessed by means of the Kolmogorov-Smirnov normality test, and homogeneity of the variances, assessed by means of the Levene test.

The ANOVA was carried out according to a split-split-plot design [6] with one (the sprayer setup, first year) or two (air flow rate and forward speed, second year) main plot factors, three sub-plot factors (row, sector, and layer of sampling), and one sub-sub-plot factor (growth stage). Mean separation was performed according to the Newman-Keuls test, at 5% level of significance. All statistical analyses and graphical representations were carried out using the open source software R [14].

3. Results and discussion

3.1 *Morphological measures of the vineyards*

In both years and stages, the canopy was about 0.85 m thick in sectors S1 and S6, about 0.45 m thick

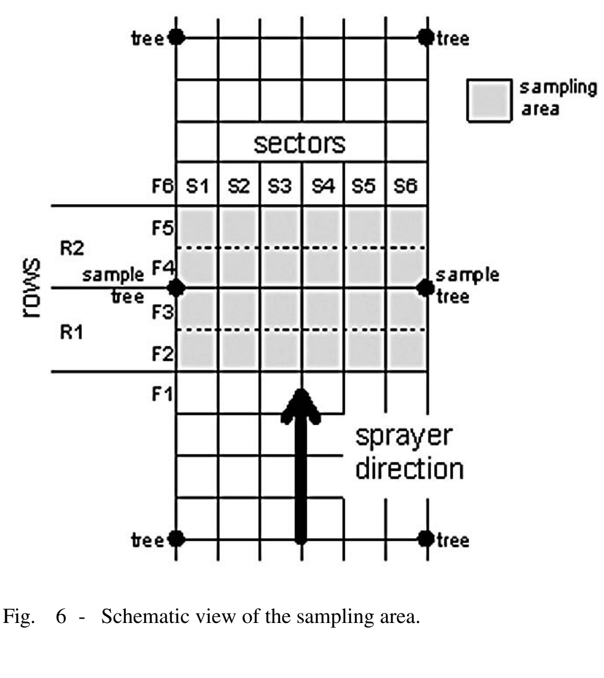

Fig. 6 - Schematic view of the sampling area.

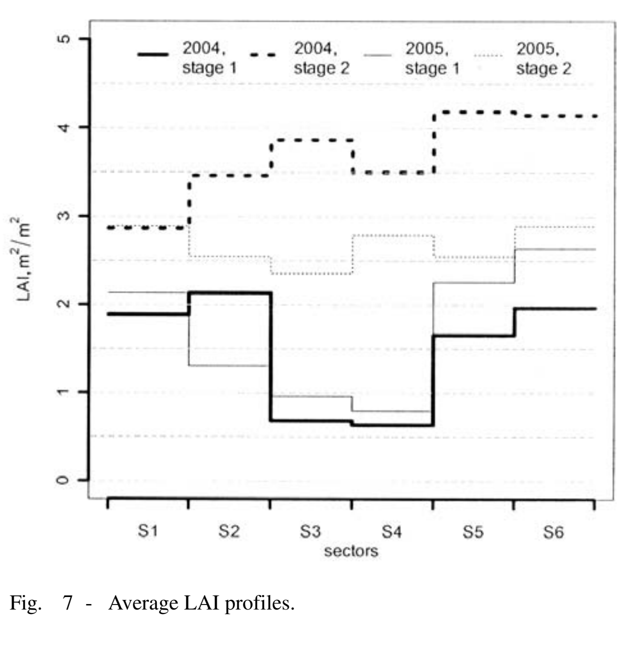

Fig. 7 - Average LAI profiles.

in sectors S2 and S5 and about 0.25 m thick in sectors S3 and S4, while the average LAIs were: 1.50 m^2/m^2 (2004, first stage), 1.68 m^2/m^2 (2005, first stage), 3.67 m^2/m^2 (2004, second stage) and 2.67 m^2/m^2 (2005, second stage). The average profiles in each sector are showed in Figure 7.

3.2 *Foliar deposition - 2004*

Due to a mechanical malfunctioning of the farm sprayer in the second stage, that prevented the experimental tests, the Stage × Sprayer combination was considered as a single factor (Treatment) with five levels.

The mean foliar deposit can be observed looking at the plot-design (Figure 8). This graph reports a horizontal segment showing the grand mean (0.238 $\mu L/cm^2$), crossed by several vertical segments, one for each factor included in the ANOVA. The mean values of the levels of that factor are reported on each vertical segment. So, S1T1, S1T2 and S1T3 represent the first stage (S1) mean foliar deposit with sprayer T1, T2 and T3 respectively, while S2T2 and S2T3 represent the second stage (S2) mean foliar deposit with sprayer T2 and T3. In like manner, A and B mean the leaves picked in the lower layer of the canopy, while C and D those picked in the upper layer. At last, B1, B2 and B3 represent the mean foliar deposit in the three replicates.

In order to deeply investigate the Treatment factor, the contrasts reported in Table 2 were performed. The first contrast compares the first with the second stage and shows a higher mean foliar deposit in the first stage. This is due to the lower LAI of the vineyard in the first stage, so, being equal the volume rate, the foliar deposit was higher. The second contrast does a comparison between the farm sprayer and the prototype in the first stage and shows no significant differences in mean foliar deposit. The third contrast compares the two configurations of the prototype in the first stage: no significant difference exists between

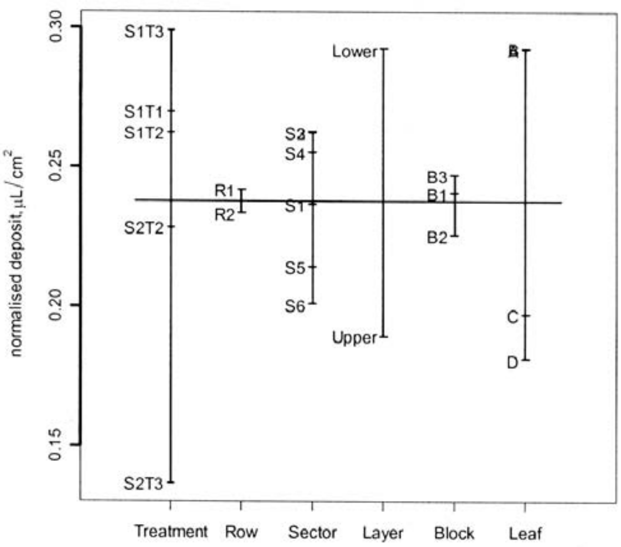

Fig. 8 - Plot-design of the first-year data.

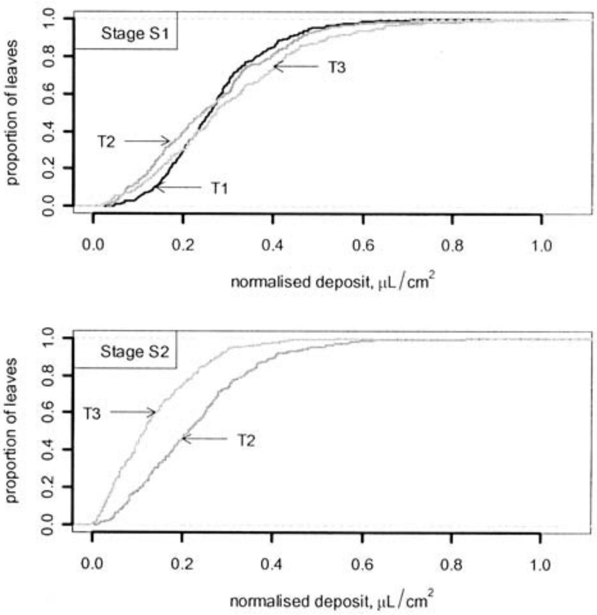

Fig. 9 - Cumulative distribution of the normalised deposits.

them. Finally, the last contrast does the same comparison in the second stage and shows a higher foliar deposit with configuration T2.

The best overall uniformity, expressed as coefficients of variation (CV), was obtained with the farm sprayer (Table 3), probably thanks to the greater airflow rate and volume rate delivered, as it is well-established that decreasing both these parameters, get worse the uniformity [4, 5].

Analysing the cumulative distributions of the normalised deposits, Figure 9 shows that the farm sprayer produced in the first stage the lowest percentage of leaves with small deposit. On the other hand, the prototype behaved differently in the two stages: better performances in configuration T3 in the first stage and better performances in configuration T2 in the second stage. We presumed that the better per-

Contrast		L.C.L.	Value	U.C.L.
1	S1 vs S2	0.070	0.107 *	0.144
2	S1: T1 vs (T2+T3)	-0.049	0.001 ns	0.051
3	S1: T2 vs T3	-0.091	-0.032 ns	0.027
4	S2: T2 vs T3	0.056	0.113 *	0.169

L.C.L.: 95% lower confidence limit; U.C.L.: 95% upper confidence limit.

TABLE 2 - Contrasts among levels of the Treatment factor.

Stage	T1	T2	T3
Stage S1	43%	58%	58%
Stage S2	-	59%	73%

TABLE 3 - Coefficients of variation of the normalised deposit.

formance of the prototype in configuration T2 in the second stage was due to a greater overlap of the air-streams released by each spraying module, resulting in a more efficient transportation of the droplets through the targets. This was emphasized by the greater LAI value in this stage.

Looking at the deposition on the canopy, the ANOVA didn't show significant differences between the two rows, but only between the lower and upper layer and among the six sectors. Both differences were statistically influenced by the Treatment factor.

The mean foliar deposit on the lower layer was 0.293 μL/cm^2, while that on the upper one was 0.189 μL/cm^2: this difference is very difficult to reduce as the canopy is sprayed on the lower side only. In the first stage the two values were: lower layer = 0.328 μL/cm^2, upper layer = 0.234 μL/cm^2 (ratio = 1.40), while in the second stage they were: lower layer = 0.245 μL/cm^2, upper layer = 0.124 μL/cm^2 (ratio = 1.98). The greater ratio in the second stage is sign of the greater difficulty in reaching the upper layer, due to the higher LAI of the vineyard.

The interaction Treatment × Layer is graphically represented in Figure 10. It shows a lower foliar deposit on both lower and upper layer with the prototype in configuration T3 in the second stage. On the other hand, in the first stage the prototype in the same configuration produced the highest deposition on the lower layer. Furthermore, in the first stage, the farm sprayer, equipped with an axial fan that delivered a greater airflow rate, produced the highest deposition on the upper layer, even if not statistically significant.

Finally, Figure 11 reports the normalised foliar deposit on the six sectors for each treatment, together with the coefficients of variation among the mean values. The lower deposition on the extremity sectors (S1, S5 and S6) is related to the greater LAI and thickness of the vegetation just in these sectors. In both phenological stages, the best transversally uni-

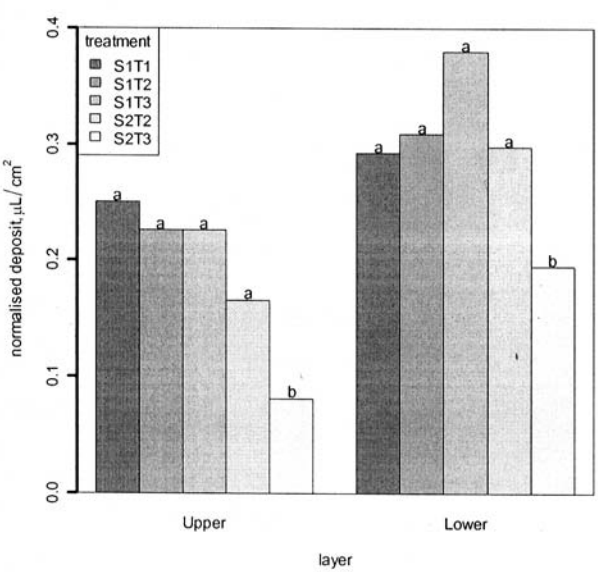

Fig. 10 - Normalised unitary deposit on the two layers (mean separation at each layer by Newman-Keuls test at 5% level).

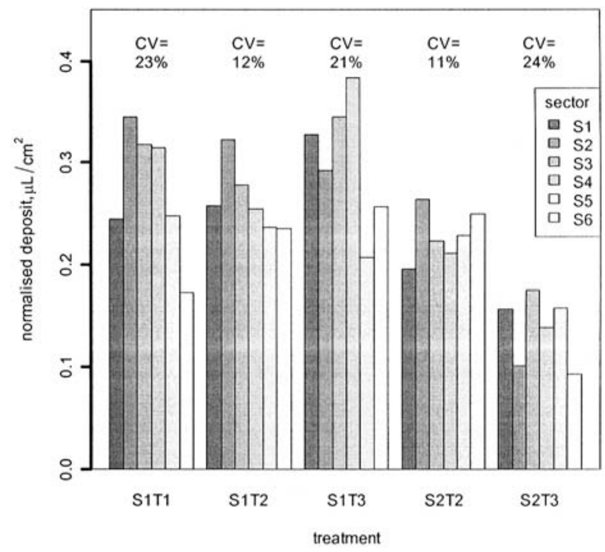

Fig. 11 - Normalised unitary deposit on the six sectors for each treatment.

formity was fulfilled with the prototype in configuration T2, perhaps again thanks to the better overlap of the air-streams released by the spraying module.

Keeping these results in mind, in 2005 we decided to continue the experimentation with the sprayer in configuration T3, to verify if its performance could be improved varying forward speed and airflow rate, after changing the fan with a greater model.

3.3 *Foliar deposition - 2005*

The ANOVA showed no effect of the airflow rate on the mean foliar deposit in both growth stages: on average, the foliar deposition was greater (not statistically significant, Figure 12) with the lowest airflow rate. The CVs were 50% with A_1 and 48% with A_2.

Also the forward speed did not influence the mean foliar deposit, but it had opposite effects (p = 0.043) in the two phenological stages (Table 4). In fact,

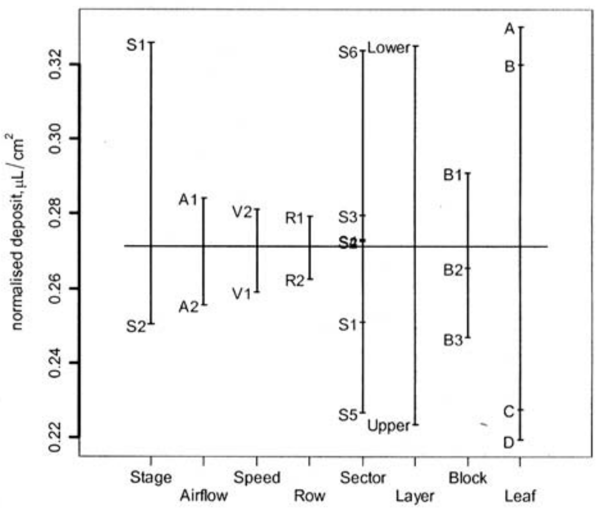

Fig. 12 - Plot-design of the second-year data.

Stage	Speed		Layer	
	1.05 m/s	1.58 m/s	Upper	Lower
S1	0.356[a]	0.313[b]	0.298[b]	0.369[a]
S2	0.237[b]	0.264[a]	0.189[b]	0.312[a]

Sectors					
S1	S2	S3	S4	S5	S6
0.251[ce]	0.273[bcd]	0.280[b]	0.273[bc]	0.227[e]	0.324[a]

TABLE 4 - Normalised deposit (mean separation at each stage and among sectors by Newman-Keuls test at 5% level).

while in the first stage there was a greater foliar deposition with the lower speed (1.05 m/s), in the second stage the deposition was greater with the higher speed (1.58 m/s). This result had repercussions on the variability: in the first stage, the CV was lower with 1.05 m/s (41% vs 43%), while in the second stage was lower with 1.58 m/s (49% vs 52%).

Table 4 also reports the average foliar deposition on the six sectors: the CV among the six mean values was 12%, mainly due to the big difference between the sector S5 and S6. This was due to a not perfect orientation of the sixth (from the left, Figure 3) spraying module, so the spray jets from the sixth and seventh modules partially overlapped on the sector S6. As a consequence, the foliar deposition was lower on the sector S5 and higher on the sector S6. In spite of that, the transversal CV was only 12%, much lower than that realised in both stages of the previous year (21% and 24%).

Finally, Table 4 shows the mean foliar deposition on the two layers at each stage. As expected, the deposit on the upper layer in the second stage was much lower, due to the increase in the LAI of the vineyard. On the other hand, the interactions Airflow × Layer and Airflow × Stage were not statistically significant, meaning that the increase in the airflow rate did not improve the deposition on the upper layer in both stages. Moreover, the difference between lower and upper layer was greater in the second stage than in the first stage, showing that the air-stream was inadequate to improve the spray penetration in the foliage.

The difference between the two stages was highly significant, certainly due to the different LAI: 0.326 μL/cm^2 (stage S1) vs 0.250 μL/cm^2 (stage S2). To this aim, collecting the two years data from the prototype with the spray boom open, the graphical representation of Figure 13 was obtained. Each point represents the mean foliar deposit on each sector for every stage and year. The linear regression is highly significant for $p < 0.001$ and accounts for the 68% of variability in the data. This result confirms the trend obtained by Pergher in [11]. Being $A_1 = 1.81$ m^3/s very close to the first year airflow rate (1.78 m^3/s), this result shows that the higher normalised deposit obtained in the second stage 2005 with respect that obtained in the second stage 2004 was mainly due to the lower LAI.

Therefore airflow rate and forward speed did not influence the mean foliar deposition, but only the uniformity (overall CV and CV in transversal direction (sectors S1 - S6)).

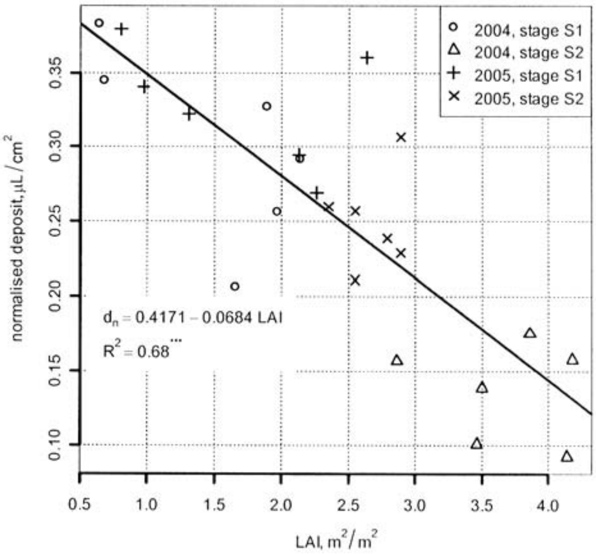

Fig. 13 - Normalised unitary deposit vs LAI using the prototype with the configuration of Figure 3.

4. Conclusions

These first results allow drawing the following conclusions about the new model of sprayer:

First year test:

- The comparison among the conventional sprayer and the prototype in both configurations did not produce statistically significant differences in the mean foliar deposition. However, the farm sprayer produced the best uniformity among the leaves (lowest CV), perhaps thanks to the higher volume rate and airflow rate. In the first stage, the highest deposition in the internal layer of the canopy was obtained with the prototype in the configuration with the spray boom open.
- At full foliage development (LAI=3.67 m^2/m^2), the prototype with the spray boom closed showed better performances, suggesting the need to operate at higher airflow rates or lower speeds when the spray boom is open.

Second year test:

- After changing the fan sprayer with a greater diameter model, the second year tests, carried out with the spray boom open, showed no statistically significant differences in mean foliar deposits between low and high airflow rate in both phenological stages. The higher mean normalised deposit achieved in the second stage with respect the first year was therefore mainly due to the lower LAI.
- Forward speed gave opposing effects in the two phenological stages: higher deposits at lower speed in the first stage and higher deposits at higher speed in the second stage.

Further experimental tests are necessary to better assess the performances of the prototype, comparing both the configurations at different forward speeds and airflow rates and measuring also the deposition on the bunches of grapes. Further improvements could be obtained fitting the prototype with an axial fan to increase the capability of the spray jet to penetrate the canopy, or increasing the number of the spray modules to realise a greater overlap while spraying. Finally, the prototype could be more versatile than the traditional sprayer to meet the different condition of the vineyard during its growing. In fact, keeping in mind the results of the first year, it could be used with the spray boom open during the first stage of growth, and after with the spray boom closed.

5. Acknowledgements

The Authors acknowledge Dr. Giuseppe Tornello, Dr. Luciano Caruso and Dr. Silvio Balloni for their valuable help during the experimental tests and the Nobili Company to have placed the prototype at our disposal.

6. References

[1] BALSARI P., TAMAGNONE M., *The Necessity to Determine the Correct Amount of Air to Use in Airblast Sprayer* Proceedings on CD-ROM of the AGENG98, 24-27 August 1998, Oslo.

[2] CERRUTO E., *Influence of Airflow Rate and Forward Speed on the Spray Deposit in Vineyards*, Riv. di Ing. Agr., (2007), 1, 29-36.

[3] CERRUTO E., *Further Studies on the Variation of Spray Deposits in Vineyards with Airflow Rate and Volume Rate*, Riv. di Ing. Agr., (2007), 1, 71-78.

[4] CROSS J.V., WALKLATE P.J., MURRAY R.A., RICHARDSON G.M., *Spray Deposits and Losses in Different Sized Apple Trees from an Axial Fan Orchard Sprayer: 1. Effects of Spray Liquid Flow rate*, Crop Protection, (2001), 20, 13-30.

[5] CROSS J.V., WALKLATE P.J., MURRAY R.A., RICHARDSON G.M., *Spray Deposits and Losses in Different Sized Apple Trees from an Axial Fan Orchard Sprayer: 3. Effects of Air Volumetric Flow Rate*, Crop Protection, (2003), 22, 381-394.

[6] GOMEZ A.K., GOMEZ A.A., *Statistical Procedures for Agricultural Researches, Second Edition*, John Wiley & Sons, 1984.

[7] GUARELLA P., PASCUZZI S., *L'attività svolta dall'U.O. di Bari*, in "Ottimizzazione della regolazione delle macchine per i trattamenti fitosanitari alla coltura della vite, finalizzata alla riduzione dell'impiego del prodotto fitoiatrico e all'impatto ambientale", printed by DEIAFA, (2002), 113-158.

[8] GUARELLA P., PASCUZZI S., *Sistema di misura informatizzato per il controllo e la taratura di irroratrici,* Riv. di Ing. Agr., (2002), 4, 1-8.

[9] ITALIAN CENTRAL STATISTICS INSTITUTE, www.istat.it.

[10] PERGHER G., *The Effect of Airflow Rate and Forward Speed on Spray Deposition from a Vineyard Sprayer*, Riv. di Ing. Agr., (2006), 1, 17-23.

[11] PERGHER G., GUBIANI R., *The Effect of Spray Application Rate and Airflow Rate on Foliar Deposition in a Hedgerow Vineyard*, Journal of Agricultural Engineering Research, (1995), 61, 205-216.

[12] PEZZI F., RONDELLI V., *The Performance of an Air-assisted Sprayer Operating in Vines*, Journal of Agricultural Engineering Research, (2000) 76, 331-340.

[13] PLANAS S., SOLANELLES F., FILLAT A., WALKLATE P., MIRALLES A., ADE G., PEZZI F., VAL L., ANDERSEN P.G., *Advances on Air-Assisted Spraying on the Mediterranean Orchards (Fruit, Vine and Citrus)*, Proceedings on CD-ROM of the AGENG98, 24-27 August 1998, Oslo.

[14] R DEVELOPMENT CORE TEAM (2006). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, http://www.R-project.org.

[15] SALYANI M., WITHNEY J.D., *Ground Speed Effect on Spray Deposition Inside Citrus Trees*, Transactions of the ASAE 33 (2), March-April, 1990, 361-366.

[16] SALYANI M., FAROOQ M., *Effect of Sprayer Airflow on Spray Movement within Tree Canopy*, Proceedings of the VII Workshop on Spray Application Techniques in Fruit Growing, 25-27 June 2003, Cuneo, Italy, 227-235.

SUMMARY

The present paper reports the results of some spray application tests carried out in tendone vineyards to assess the performance of a new model of sprayer whose spray boom, made of seven adjustable spraying modules, partially meets the geometry of the vegetation. Two configurations were taken into consideration: spray boom closed (T2), to improve the in field manoeuvrability, and spray boom open (T3), to approach the target with the spray modules.

The experimentation was carried out within a period of two years, comparing the two prototype configurations with a conventional sprayer (T1, first year) and the effects of airflow rate and forward speed of only the prototype T3 (after we have changed the fan) on the foliar deposition (second year).

An experimental design with one (the sprayers setup, first year) or two (airflow rate and forward speed, both with two levels, second year) factors was adopted, arranged according to a randomised block design with three replicates. To take into account the development of the vegetation, the experimental plan was replicated in two phenological stages: "Berries pea sized" and "Berry touch" (first year), and "Berries pea sized" and "Beginning of ripening" (second year).

The first year results showed no statistically significant differences in the mean foliar deposition among the three sprayer setup, but a better uniformity with the farm sprayer in the first stage, perhaps thanks to the higher airflow rate and volume rate delivered. In the second stage, the prototype in configuration T2 was better than in configuration T3, both as uniformity and mean deposition. The second year results showed no effect of both airflow rate and forward speed on the mean foliar deposition, so the higher value achieved in the second stage with respect the first year was mainly due to the lower LAI.

Key words:
Sprayer, Crop protection, Foliar deposition.