第二届植保机械与施药技术国际学术研讨会论文集

Proceedings of 2nd International Workshop of Plant Protection Machinery and Application Techniques

（2010 年 9 月 15-17 日，中国北京）

（Sep. 15th-17th 2010 Beijing，China）

主 编

何雄奎 邵振润 张钟宁

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Part One

第一部分

A Study of Dosage Adjustment for Pesticide Application in Vineyards

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Abstract: Traditional pesticide application in grapevines causes large losses to the air and the ground, particularly in early to mid-season application. Traditional application rates do not differ very much according to the season. Pesticide labels for vineyard sprays are based upon ground area, but growers choose different row widths, varieties and trellis designs, so canopy volume varies. Dosage adjustment, according to the fruit canopy characteristic, has been developed. In the trial described in this paper, three of them, Unit Canopy Row (UCR) (Australia), DOSAVIÑA (Spain and USA) and Fruit-Wall Area (FWA)(Germany and Belgium) are compared with the traditional application rates and their pros and cons are discussed. This paper presents the methodology and experimental results of the study.

Sampling methods affect the results of pesticides distribution through the grape canopy significantly, due to leaf size variation within the canopy and individuals not selecting leaves from the same area of the canopy. A new tool was designed, in favor of sampling more precisely. Evaluation of the tool was carried out in the field.

Two trials have done until now. Results demonstrated that at early growth stage, deposition of DOSAVIÑA and LWA was not different significantly from that of traditional method; deposition was not different significantly from each other among DOSAVIÑA, LWA and UCR, (application rate was 327, 281, 234 and 187 L/ha for traditional, LWA, DOSAVIÑA and UCR, respectively). At middle growth stage, LWA and traditional methods still achieved similar results, while deposition of DOSAVIÑA and UCR was not different significantly, when application rate for traditional model increased to 700 L/ha, for LWA, DOSAVIÑA and UCR, 560, 327 and 374 L/ha, respectively. The results shown high potential of reducing application rates using alternative models compared with traditional way, also emphasizes the importance of changing air from sprayer in terms of reducing the volume and speed by a louver system or changing the nozzle orientation.

Key words: Sampling method, UCR, DOSAVIÑA, Fruit-Wall-Area, Vineyard spraying

1 Introduction

It's well known that application techniques on field crops and orchards or grapevines are different. As for field crops (sometimes, cotton, tomato, and band plants are exclusive),

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the effects of plant height and leaves on flow rates are neglectable; the ground under the crops can be considered as the targeted area, while for vertical high crops (orchards and vineyards), the ground area is not the proper parameter to which the dose rates are adjusted, even the pesticide labels still persist the ground area dominant tradition and are registered to be applied on all the crops irrespective of the canopy structure.

Most pesticides used in USA are expressed in oz (ounce) per acre. It's difficult for a vineyard grower to make it clear how to choose the right dose rate. Three kinds of row distance exist in American vineyard training systems, i. e. 2. 7 m (traditional), 2. 1 m (modern) and 1. 2 m (the others). The pesticide label registration procedures are usually based on traditional row distance of 2. 7 m, so 29% and 125% less of pesticides should be applied on modern vineyard and vineyard of 1. 2 m row distance, respectively, if other operational parameters are kept constant, such as variety, growth stages, training system, and so on. Even for the same vineyard, no doubt that canopy characteristics like canopy height, width and density change tremendously along the growing season. Leaf area can change from nothing during the dormant time to over 23 000 m^2 per hectare at the later growth stages (Siegfried et al, 2007). The fixed rate application method may cause over dosing at early growth stage, when big gaps exist in the canopies, and under dosing at later growth stage, which results in less active ingredients being applied, which in turn may result in pest resistance (Furness and Magarey, 2000). The pruning system also affects the deposition significantly (Balsari, 2004).

The vineyard growers are prone to shut off top nozzles to reduce the dosage rate at early stage, sometimes, are encouraged by the pesticide manufacturers. What they always do depends on their experiences, while the scientists have trying to develop some models to match the changeable canopy structures. The short summaries of chosen models listed below are also what we used in the trial:

DOSAVIÑA is Excel based software developed by Gil (Gil and Escola, 2009). It's originated in Spain, and further modified to use in New York and Pennsylvania (Landers and Gil, 2009). The software is convinced as its data are from several years of results in real conditions using different types of sprayers. It involves three main screens, data input, results and information. Parameters such as crop characteristics (growth stages, dimensions, structure and parcel layout), sprayer and nozzle type are taken into account. The real volume rate is corrected by a factor of efficiency from the theoretical volume at the last step. The theory behind the software is Tree Row Volume (TRV), i. e. cubic m of canopy per hectare. The TRV value is calculated by canopy width multiplies canopy height multiplies row length per hectare.

DOSAVIÑA is proved by a continual trial lasted four years from 2006-2009 in New York (Landers and Gil, 2009). The traditional method is performed as control. The results demonstrated the minimal 30% saving on pesticide costs without any loss of biological efficacies.

Unit Canopy Row (UCR): this method is initiated by Furness et al. (1998) in Australia to reduce the variability and increase the biological efficiencies caused by the fixed rate method (Furness, et al., 2006). UCR is considered as the modified version from TRV, and has an advantage of being simpler to use in the field. Two concepts are defined in the UCR method, appropriate spraying volume (ASV, the volume needed to wet the targeted foliage per UCR), and maximum spraying volume (MSV, the volume sprayed until runoff for both outer and inner foliage surfaces).

The UCR method has a potential of reducing pesticides in excess of 50% (Furness, et al., 1998). Barani et al. (2008) tested the model and indicated satisfactory results and similar level of pest control as standard spraying practice using only one fifth of both spray volume and active ingredients, where the fruit zone was the target.

Leaf wall area (LWA): the vineyard canopy displays a wall of leaves, especially at trellis training system and after pruning. The LWA method was launched in Germany by Koch (2007). In this method, the priority of the appropriate dose expression is the sprayer function. The formula for boom sprayers still works for vineyard sprayers, if the treated area is defined as a virtual plane between nozzles and canopy.

The linear relation between pesticides delivered per 10,000 m2 leaf wall area and deposits expressed in ng cm-2, was derived from experiments on apple orchards, which was thought to be the rationale behind the LWA method (Weisser and Koch, 2005). Trials investigating the LWA method shown that it reduced the variability of deposits in the canopy, and saved an average of 29% of dose rate, when the traditional method was compared (Pergher and Petris, 2008).

The objectives of this program are to study the potential of reducing the application rates in vineyards located in New York using LWA, UCR and DOSAVIÑA methods in terms of deposits and distribution of pesticides in the canopy. The sprayer was calibrated by orientating the nozzles to match the canopy and reducing the air flow emitted through a louver system to improve the spray quality.

2 Methods and materials

2.1 Experimental date

Two trials have finished until now and the third one is planned to be done in early August, corresponded to the early, middle and late growth stage, respectively. The first trial was done on 20 May 2010, while the second one was on 8 June 2010.

2.2 Treatments

Four treatments were carried out for each trial: (i) traditional method, (ii) Leaf Wall Area (LWA) method, (iii) DOSAVIÑA method, and (iv) Unit Canopy Row (UCR) method. The only variable among the treatments was the different application rates according to the certain growth stages using a normal air-blast sprayer. Canopy size was measured one day before the trial. Ten points were selected randomly the blocks and the mean values (Table 1) were used to calculate the canopy volume, on which the application rates were based (Table 2). The widths and heights were measured at the same points. The issue to be emphasized was to ignore the sparse cane protruding from the canopy.

Table 1 The mean values of canopy size and standard deviation values in parenthesis measured at individual growth stage

Canopy size	May 20	June 8
Width (m)[a]	0.6 (0.12)	0.7 (0.08)
Height (m)	0.6 (0.15)	1.1 (0.05)

[a] Mean values calculated based on 10 measurements.

Table 2 Flow rates (L/ha) for each treatment calculated based on individual formula at two grow stages

Treatments	Traditional	LWA[a]	DOSAVIÑA	UCR[b]
May 20	327	280	234	187
June 8	700	560	327	374

[a] LWA= Leaf Wall Area, [b] UCR= Unit Canopy Row

2.3 Vineyard

The trials were conducted in a vineyard of 130 rows at Ovid, NY. The vineyard comprised var. GR7 on a vertical shoot position (VSP) trellis system. The distance was 2.7 m between the rows and 2.1 m in the row. Grapevines were planted in 1992.

2.4 Sprayer settings

All treatments were applied using a conventional air-blast sprayer (Berthoud, Simoun 600). The operational parameters of the sprayer were kept constant for the whole experiment, except for the flow rates. Different flow rates were generated by Lechler hollow cone nozzles (Lechler Inc. 445 Kautz Road, USA) at different pressures (Table 3). Four nozzles

Table 3 Operating parameters of the air-blast sprayer for each treatment

Treatments	Traditional		LWA[a]		DOSAVIÑA		UCR[b]	
Sprayer	1[c]	2[d]	1	2	1	2	1	2
Nozzle type[e]	Green	Blue	Green	Blue	Green	Blue	Orange	Green
No. nozzles	8	10	8	10	8	10	8	10
Pressure (Bar)	8.27	5.52	5.52	3.45	3.65	4.69	5.72	5.86
Flow rate (l min^{-1})	7.32	15.48	6.21	12.38	5.15	7.23	4.13	8.25
Speed (km h^{-1})	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
PTO speed (rpm)[f]	2 850	2 850	2 850	2 850	2 850	2 850	2 850	2 850

[a] LWA= Leaf Wall Area, [b]UCR= Unite Canopy Row, [c]1= May 20, [d]2= June 8

[e]Nozzle type= Lechler TR & hollow cone nozzles, [f]PTO speed from manufactures information

per side were fitted for the first trial while five nozzles per side for the second trial. The nozzle orientation was adjustable to match the canopy structure, especial at the early growth stage. The air volume from the sprayer was controlled by a louver system developed by Cornell with the aim to reduce the drift from the targeted row. The nozzle orientation and air volume was tested just before the trials commenced on similar rows far from the blocks.

2.5 Experimental design

Experimental design was randomized block involved five plots for each treatment. The plot consisted of a panel of three vines. At least three panels were buffered between each plot or from the end of row, and two rows between each block to prevent contamination from each other. The rows were sprayed from both sides of the sprayer.

The middle vines of each plot were used for sampling. The leaves were picked from each sampling zone as soon as one treatment was done. All trial was finished within two hours to limit the errors caused by the light-sensitive tracer dye. To make the sampling procedure prompt and accurate, a tool was designed to have 2.1 long and 0.5 m wide. The horizontal bars were to mark different sampling heights. The leaves between two bars were picked randomly, then were stored in an ice box and transported to the laboratory where they were kept in refrigerator at low temperature until the extraction.

2.6 Tracer and sampling

A yellow dye, Tartrazine, was used for deposition at a concentration of 2 g/L. Samples of tank solution were put into tubes before and after the trials to check the concentration.

For the first trial, the canopy was divided into four zones, two vertical heights and two horizontal depths. The middle and central parts were exclusive due to the narrow canopy width and limited height. Five leaves were sampled from each zone. For the second trial, the leaves were picked from seven zones, three vertical heights on both sides of canopy and one central part. Three leaves were sampled for each bag.

When in laboratory, the dye was washed off by 50 ml of deionized water. The bags were locked and shaken for 30 s, and then the concentrations in the bags were determined using Plate CHAMELEON TM multilabel counter (Hidex, Turku, Finland) equipped with MikroWin 2000 Hidex driver software. The leaves were taken from the bags and dried, then were scanned. The areas of leaves were measured by image analysis software (APS Assess, The American Phytopathological Society, St. Paul, Minnesota). A 40-fold dilution of the tank solution was used as a calibration standard for the spectrophotometer. All the data were normalized to the concentration of 2 g/L. Final deposits were expressed in $\mu g/cm^2$.

2.7 Meteorological measurements

The meteorological conditions (Table 4) included temperature, relative humidity and windy speed at the time of application were monitored by WatchDog Model 2700 Weather

Station (Spectrum Technologies, Inc. Illinois, USA). The measurements were conducted at a height of 1.5 m above the ground and 10 m from the vineyard. Data were recorded until all the treatments were finished.

Table 4 Meteorological conditions for the two trials

Canopy size	May 20	June 8
Wind speed (m s^{-1})	2.07	2.57
Relative humidity (%)	45	55
Temperature (°C)	21.7	17.2

2.8 Statistical analysis

All data were examined for equality of variance using Levene's test across the four treatments and five replicates prior to analysis. Data were log or X2 transformed if necessary. Tukey's HSD test (SPSS, SPSS Inc.) was used for multiple comparisons and the significance level was. Furthermore, coefficients of variation were calculated for the array of values affected by different sampling zones, locations and flow rates.

3 Results

3.1 Deposits on leaves for the first trial

Analysis of variance indicated that the average deposits were significantly affected by treatment ($P= 0.035$) and height ($P=0.001$), not by side (Table 5). More application rate achieved more deposits on the leaves (Table 6), though there were not statistical significant differences among the UCR, DOSAVIÑA and LWA; neither were among the DOSAVIÑA, LWA and Traditional methods. From table 6, it shown that no significant differences were observed among the four treatments on different locations, except for the left top, where the deposits of UCR were less significantly than that of Traditional, but not than that of DOSAVIÑA and LWA. The application rate of Traditional, even after adjustment by the growers themselves, is still higher than what is needed on the leaves in the view of deposits. Consider the vulnerable to pests and disease at early growth stage; it's safer to apply the rate of DOSAVIÑA, however, under lighter pests and disease pressure condition, it's acceptable to use the rate of UCR.

Deposits on the bottom of the canopy tended to be larger than top parts. Gil et al. (2007) also found the same trend. During the trial, the top nozzle was shut off in order to control drift beyond the canopy, however, there should be some balance between the enhancement of deposits on the top of canopy and the reduction of drift in the air. The long distance between the nozzles to the top zone and the filter effect by the leaves also contributed to the final results.

Table 5 Analysis of Variance for normalized deposits (μg/cm²) at early stage

Source of Variance	df	Mean Square	*F*	*P*
Treatment	3	2.343	3.046	0.035
Side	1	0.145	0.188	0.666
Height	1	9.221	11.984	0.001
Treatment * Side	3	1.491	1.938	0.132
Treatment * Height	3	0.477	0.62	0.605
Side * Height	1	0.032	0.042	0.839
Treatment * Side * Height	3	0.566	0.735	0.535
Error	64	0.769		

Table 6 Normalized deposits (μg/cm²) on different parts of the vines at early growth stage

Treatments	Locations				Average
	Right-top	Right-bottom	Left-top	Left-bottom	
UCR2	2.10 a[1]	2.10 a	1.22 a	1.70 a	1.78 a
DOSAVIÑA	1.74 a	2.83 a	1.98 a b	2.76 a	2.33 a b
LWA 3	1.72 a	2.26 a	2.19 a b	3.17 a	2.34 a b
Traditional	1.87 a	3.12 a	2.54 b	2.86 a	2.60 b

[1] Values followed by the same letter in columns do not differ statistically (Tukey HSD test, $p < 0.05$)

[2] UCR= Unit Canopy Row; [3] LWA= Leaf Wall Area

3.2 Deposits on leaves for the second trial

Table 7 demonstrated that different treatments and heights affected the deposits significantly; the same trend had been shown in the first trial. Carefully adjustment of orientation of nozzles for both sides of sprayer achieved positive results (P= 0.733).

Table 7 Analysis of Variance for normalized deposits (μg/cm²) at middle stage

Source of Variance	df	Mean Square	*F*	*P*
Treatment	3	0.31	28.960	0.000
Side	2	0.003	0.311	0.733
Height	2	0.871	81.443	0.000
Treatment * Side	6	0.010	0.896	0.500
Treatment * Height	6	0.020	1.894	0.088
Side * Height	2	0.001	0.054	0.948
Treatment * Side * Height	6	0.002	0.148	0.989
Error	111	0.011		

For the second trial, the application rates ranged from 327 L/ha (DOSAVIÑA) to 700 L/ha (Traditional), two times for the largest rate more than the lowest rate. The results shown in Table 8 that, deposits of UCR were significantly less that of DOSAVIÑA, which in turn less significantly than that of LWA and Traditional. Higher rate still dominated the

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