Evaluation of pesticide losses and drift during treatments in vineyard

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In viticulture, several fungicides are applied following numerous treatments to protect grapevine from pests. As fungicides are applied to the foliage, less attention has been paid on their fate in soil, if compared to herbicides. However, due to uneven distribution, almost every application produces some amount of drift off the target area and fungicides losses to soil (Komarek et al., 2010).
In this research, penconazole application was followed to determine the amount of fungicide losses and drift during treatments performed under good agricultural practice. Penconazole is widely used and repeatedly applied in vineyard. It is a persistent active substance in soil and water with a potential environmental threat. In the experiment performed, traps were placed along mid-rows as well as along the vineyard downwind perimeter with the aim to asses losses and drift of penconazole under real operative conditions. A further aim was to assess the spatial variability of penconazole concentration within and outside the vineyard.
The study was carried out at experimental farm of Università Politecnica delle Marche, Ancona, Italy, 43 °32'48 "N, 16 ° 22'00 E, 80 m a.s.l.. In a 2.2 ha of vineyard penconazole was applied three times (in a 22-day period) as commercial product by using a SAE Turbomatic atomizer (tank volume 500L) attached with Albuz noozles 1, 1.2, 1.5 mm Ø. Glass traps (Ø 15 cm) containing filter paper were placed in seven sampling points (one each 9 m) along each of six mid-rows (63 m long, 2.80 m large) to measure the amount of penconazole fell towards soil during treatments as consequence of the application to foliage.
Only at the first fungicide treatment, drift was assessed placing 32 glass traps in four rows at 5, 10, 15 and 20 m distance from the downwind field limit (8 traps per row at 10 m distance each other).
All the traps were collected and placed in heat insulated bags with ice packs to prevent the degradation of the active ingredient and stored at -10 ° C until analysis. Analytical-grade of penconazole (99.0%) by Dr. Ehrenstorfer GmbH, Augsburg, Germany was used as analytical standard. Filter paper of traps was extracted and extracts were injected into using a HPLC Spectra System P4000 attached with Spectra System UV1000 and equipped with a C-18 reversed phase with a flow rate of 1mL min^{-1} and a UV detector at 205 nm. Under these conditions, retention time of penconazole was 9.8 min and limit of quantification (LOQ) was 5 μg kg^{-1} for penconazole in filter paper.
Analysis of variance, LSMeans Differences Student's t were determined by using JMP's v.7 (SAS).
Table 1 shows the mean value (M), the standard deviation (STD) and the coefficient of variation (CV) (percent ratio between standard deviation and mean) of the amount of penconazole per unit of area measured in the traps during all the three applications. In the same table the Least Significant Differences (LSD) between the mean of each row for each application is reported.

Table 1 - Mean (M), standard deviation (STD), coefficient of variation (CV) and least significant differences (LSD)* of the mean separately calculated for the mean concentration of penconazole measured in traps along seven sampling points in six tested mid-rows for the three applications

	Mid rows					
	A	B	C	D	E	F
1st application (μg cm^{-2})						
M (n=7)	0.26^a	0.33^a	0.32^a	0.27^a	0.38^a	0.26^a
STD	0.17	0.18	0.15	0.08	0.178	0.16
CV (%)	65	55	47	30	47	62
2nd application (μg cm^{-2})						
M (n=7)	0.19^a	0.23^a	0.17^a	0.21^a	0.23^a	0.20^a
STD	0.15	0.08	0.12	0.16	0.12	0.09
CV (%)	79	35	71	76	52	45
3rd application (μg cm^{-2})						
M (n=7)	0.24^a	0.20^a	0.22^a	0.16^a	0.2^a	0.12^a
STD	0.10	0.09	0.08	0.10	0.15	0.07
CV (%)	42	45	36	63	75	58

* Low-case letters represent LSD at $p<0.05$

Penconazole amount varied markedly, ranging from a minimum value of 0.02 to a maximum value of 0.65, 0.41, 0.39 µg cm^{-2} after the first, second and third application, respectively. On the basis of the rate of active ingredient applied corresponding to 0.45 µg cm^{-2}, a mean amount of 67.43%, 45.80% and 42.50% of penconazole fell towards soil during first, second and third treatment, respectively.

In particular, the highest percentage of penconazole in traps (67.43%) was found after the first penconazole application and it decreased with the following treatments. Since the same climatic conditions in terms of wind speed (6-8 Km h^{-1}) and direction (S-SE/N-NO) occurred during all the three applications, the highest amount of penconazole in traps was mainly attributed to the small volume and non-homogeneous foliar density of the grapevine canopy that, at the time of the first field treatment, was at the beginning of its vegetative stage. During second and third treatment, the developed grapevine canopy became better able to intercept the product distributed and to reduce peconazole losses. Data found are in agreement with other reports (Rueegg et al., 1996) that stated that 50% in mid-april and 30% in mid-may of difeconazole and penconazole reached the soil when applied in apple orchard with an axial sprayer. The high values of the CV for data within rows show considerable variability in all applications, ranging from 30% to 65% in the first application, from 35% to 79% in the second and from 36% to 75% in the third, that was related to the uneven distribution of penconazole along the mid-rows. However, LSD of the mean showed no significant differences among the mean values of the mid-rows, due to a repetition of the factors influencing the variability that not contribute to the overall variability.

Penconazole drift is reported in Table 2, as mean, standard deviation and coefficient of variation of data at 5, 10, 15 and 20 m of distance from the downwind side of the vineyard.

Table 2 - Penconazole drift (µg cm^{-2}) measured along the downwind side of the vineyard at 5, 10, 15 and 20 m of distance, respectively. Mean value (M), standard deviation (STD) and variation coefficient (CV) of 8 traps

	Number of traps										
Distance	1	2	3	4	5	6	7	8	M	STD	CV
5 m	0.019	0.017	0.036	0.019	0.027	0.033	0.012	0.007	0.021	0.010	47
10 m	0.005	0.002	0.034	0.005	0.009	0.020	0.005	0.019	0.012	0.011	98
15 m	0.002	0.003	0.007	0.005	0.015	0.016	0.003	0.001	0.006	0.006	100
20 m	0.001	0.005	0.005	0.004	0.018	0.015	0.004	0.001	0.007	0.006	96

The fungicide was found until 20 m of distance from the vineyard limit, indicating a high drift under the conditions tested.

The mean value of the amount of penconazole measured in traps compared to the rate of penconazole applied per ha corresponded to 4,66%, 2,66%, 1,33% and 1,55% at the distance of 5, 10, 15 and 20m, respectively, in accordance with Vischetti at al. (2008) which reports that 5,4 %, 3.9% and 1.3% of the insecticide cholrpyrifos was found at a distance of 6, 12 and 18 m respectively, during a field treatment in vineyard under a speed wind of 6-16 km/h. The high spatial varibility of the data is again demonstrated by the CV values which ranged from 47 to 100%. In this case the high variability was attributed to the main direction of wind (S-SE/N-NO) which was transversal to the direction of the atomizer (S/N) leading to a different accumulation of penconazole in traps.

In conclusion, the experiment performed has evidenced that a high percentage (from 42 to 67%) of penconazole can reach the soil during the treatments and that 1.55% of this active ingredient can reach soil at 20m of distance from the downwind side of the vineyard due to drift, even if the speed of wind was in the range of that allowed in the good agricultural practice.

KEY WORDS: penconazole, vineyard, pesticide losses, pesticide drift, spatial variability

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