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# Evaluation of fungicide strategies designed to reduce the number of treatments against Grapevine Powdery Mildew

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The objective of an integrated plant protection program in vineyards is not to prevent the development of pests and diseases at any price but to limit their potential damage to the crop and the yield. The use of such a threshold concept should allow a more efficient use of fungicides, in particular limiting their number of applications whilst still ensuring the objectives of high quality production and adequate yield.

Two criteria must be taken into consideration to improve the performance of treatment strategies:
1) the positioning of the applications
2) the choice of the fungicides depending on their type of action towards the pathogen (protectant, curative or anti-sporulant).

In the case of grape powdery mildew *(Erysiphe necator)*, the main damage is caused on bunches. The period during which bunches are most sensible is relatively short and lasts approximately two weeks from flowering onwards depending on the cultivars (Gadoury *et al*, 2003). This corresponds to the period of bunch set.

A study conducted in 2004 had the objective to:
1) investigate the possibility to limit the number of applications against grape powdery mildew to three during the period when bunches are most sensitive (from flowering onwards)
2) evaluate the interest of an additional application at pre-flowering for its disease control on leaves and to strengthen the protection of the grapes.

Several spray programs based on grape powdery mildew fungicides representing the major chemical groups (except the non-organic products based on sulphur) were tested in a series of trials carried out in the major vine growing areas in Southern Europe under situations with natural or artificial infection.

Material and methods

Within a European based network of trials (Table 1), two strategies were compared: one with 4 treatments starting at stage 57 (according to BBCH scale) and one with 3 treatments starting at stage 69. In both cases, fungicides were applied every 14 days with the last application performed at the stage 77/79. One DMI fungicide *tebuconazole (*Corail EW, Bayer Germany*)*, one strobilurin, *trifloxystrobin* (Flint WG, Bayer Germany) and an association of *myclobutanil and quinoxyfen* (GF-1160, DowAgroSciences USA) were compared.

These strategies were tested under natural disease infestation conditions. A split-plot design with two factors (strategy, fungicide) with 4 replicates was used. The size of the plots were sufficiently large to ensure at least 100 bunches for assessment.

In addition to the trials run under natural infestation conditions the same treatments were also compared in 2 trials performed under artificial inoculation (table 1). A randomized design with complete blocks and 4 replicates (with control) was used. The unit plot consisted of 3 plants on a single row. The inoculation was performed on the central plant of each plot, at the stage 14/15, according to the method developed at the INRA centre of Bordeaux (Delière *et al*, 2002). The treatments started at stage 57 and only the strategy with 4 applications was performed.

Tab. 1. Characteristics of the trials network

| Name | situation | cultivar | infection |
|---|---|---|---|
| F302 | France | Carignan | natural |
| F303 | France | Carignan | natural |
| I302 | Italy | Aglianico | natural |
| S301 | Spain | Carignan | natural |
| P301 | Portugal | *unknown* | natural |
| OG3 | France | Cabernet sauvignon | artificial |
| F301 | France | Cabernet sauvignon | artificial |

Tab. 2. Rate of fungicides used in the trials

| Fungicide | Active ingredient | Rate of product/ ha |
|---|---|---|
| GF-1160 | myclobutanil + quinoxyfen(45+45 g/l) | 1.0 L |
| Flint | 50 % trifloxystrobin | 0.125 kg |
| Corail | 250 g/l tebuconazole | 0.4 L |

Incidence and severity on bunches were assessed at the stage 77/79.

Results

For all trials run under natural infection, the program of 4 applications showed significantly better mean efficacy than that obtained with the program of 3 applications (Table 3).

Tab. 3. Disease severity (%) on bunches at stage 79 (on untreated plots and mean value for each strategy) Two ways ANOVA (split plot) and Newman Keuls test - Comparison between 4 and 3 treatments strategies on natural infection trials.

| Treatment strategy | trial | | | | |
|---|---|---|---|---|---|
| | F302 | F303 | S301 | I302 | P301 |
| Untreated | 97 | 78 | 68 | 80 | 90 |
| 4 treatments | 6.6 a | 5.6 a | 6.0 a | 3.2 a | 0.5 a |
| 3 treatments | 34.6 b | 22.2 b | 28.8 b | 7.0 b | 1.8 b |
| Probability | <0.00001 | 0.0017 | 0.00036 | 0.00242 | 0.006 |

All fungicides delivered equally good efficacy within the 4 treatment program. Trifloxystrobin showed the least variable level of efficacy between the individual trial sites. Tebuconazole and the myclobutanil + quinoxyfen combination showed more variable results, though being equivalent (table. 4).

Tab. 4. Disease incidence and severity on bunches at stage 79 (mean value for 7 trials) ANOVA grouping trials with Newman & Keuls test (performed without untreated plot).

| Treatment | Incidence | | Severity | |
|---|---|---|---|---|
| | mean | SD | mean | SD |
| Untreated | 98.7 | 2.9 | 71.1 | 17.1 |
| myclobutanil + quinoxyfen | 41.2 ns | 30.0 | 6.2 ab | 5.1 |
| trifloxystrobine | 29.2 ns | 23.0 | 2.2 b | 2.1 |
| tébuconazole | 42.1 ns | 35.5 | 7.2 a | 7.6 |
| P (treatment) | 0.17 | | 0.034 | |
| p(treatment x trial) | 0.019 | | 0.218 | |
| SE | 9.5 | | 4.1 | |

## Discussion

The degree of damage observed in the non treated plots reveals very high disease levels at the various sites. In this context, the programs based on 3 applications starting at flowering do not achieve satisfactory disease control on bunches since a level of 2 % - 35 % infection was observed depending on trial site. However, the overall efficacy of the programs – close to 77 % - is still considerable. This result confirms that the protection of the newly formed berries during their stage of their highest sensibility is important but insufficient in situations with high disease pressure.

Overall, the strategy with 4 applications starting at B 57 ensures a better level of protection in all trials (mean efficacy of 95 %) and demonstrates the interest of a treatment at pre-flowering to limit the infection on bunches. These results confirm the importance of an early disease epidemic on leaves as a source of inoculum for the infection of the young berries at flowering. The damage on bunches is even more severe if the disease has started to develop on leaves situated nearby (Calonnec *et al*, 2005, Peyrard *et al*, 2005). The application at pre-flowering appears to be necessary to limit early disease spread on leaves, thus reducing the build up of stock inoculum responsible for infection on young bunches.

Although not perfect, the level of bunch protection obtained with only 4 fungicide applications is significant and consistent in different vineyards, and at the boundary of what is being considered as acceptable for production of good quality wine grapes. In fact, berries infected by late and superficial symptoms of powdery mildew (= not completely destroyed by the pathogen) and present at a proportion of < 5 % at harvest have no significant qualitative impact. They do not cause any aromatic defect "of a fungal type" which is eliminated at the first alcoholic fermentation steps (Darriet *et al*, 2002) and have only little effect on the organoleptic qualities of the produced wines with the cultivars Sauvignon and Cabernet – Sauvignon (Calonnec *et* al, 2004). Other authors indicate that very low levels of powdery mildew influence the quality of the grape (Gadoury *et* al, 2001) and mention lower acceptable thresholds of 1- 5 % (Stummer *et* al, 2005) for cultivars Concord and Chardonnay.

The performance of this type of program depends very much on the type of fungicide used. Products demonstrating curative and good protectant activity appear to be the most effective. The combination with quinoxyfen, a purely protectant fungicide (Green *et al*, 1998) and the curative molecule myclobutanil gave excellent performance equivalent to the level of tebuconazole and trifloxystrobin in these studies.

In practice, spray programs combine several fungicides of various modes of actions to limit the risk of development of resistant strains. A judicious alternation of fungicides depending on their intrinsic properties is therefore necessary in order to optimise the efficacy of strategies with a reduced number of treatments.

These results show that it is possible to reduce the number of fungicidal applications necessary to ensure the protection of the grapes against powdery mildew. The measure proposed can be optimised by improved management of protection at pre-flowering in relation to the disease pressure prevailing in the vineyard. This requires the availability of objective information on the start and the early development of the powdery mildew epidemic in the plots. The reinforcement or suppression of treatments in the case of high or very low disease pressure could be adjusted according to ability to improve protection at pre-flowering. The choice of fungicides would also be of importance in this optimisation.

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