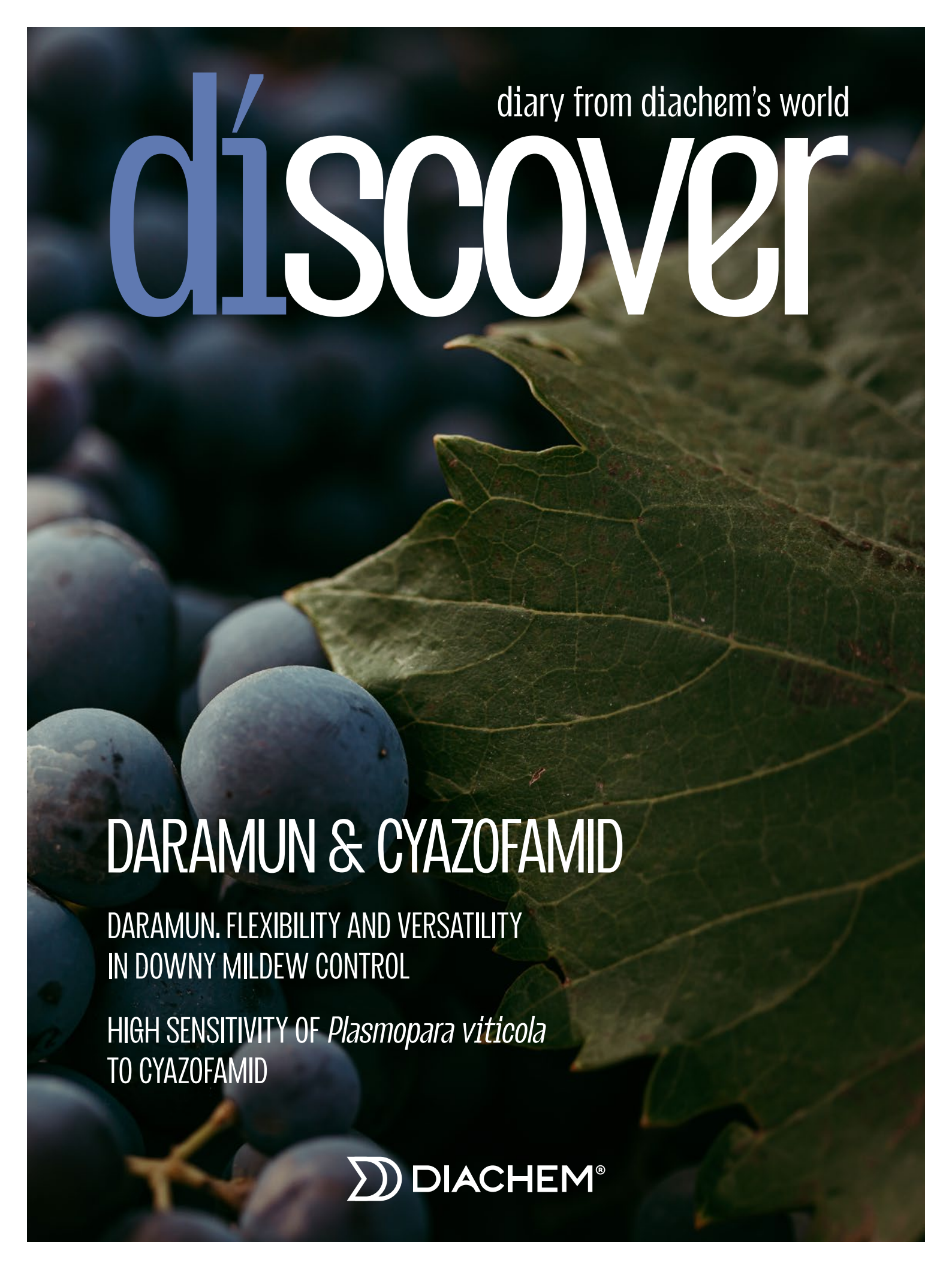




diary from diachem's world

discover

DARAMUN & CYAZOFAMID

DARAMUN. FLEXIBILITY AND VERSATILITY
IN DOWNY MILDEW CONTROL

HIGH SENSITIVITY OF *Plasmopara viticola*
TO CYAZOFAMID

 DIACHEM®

Daramun.

Flexibility and versatility in downy mildew control

Daramun by Diachem is a downy mildew fungicide based on cyazofamid. The advanced formulation of Daramun also includes a next-generation wetting agent, which ensures optimal coverage of the plant canopy

The 2023 viticultural season will be remembered for the high downy mildew pressure across many Italian wine-growing areas, including those in Central and Southern Italy, where this pathogen is normally less of a concern compared to Northern regions. However, even in years with less favourable meteorological conditions for the spread of *Plasmopara viticola*, control of this pathogen remains essential.

Downy mildew damage on grapevine

The causal agent of grapevine downy mildew, the oomycete *Plasmopara viticola*, can cause damage to both vegetative tissues and fruit. On young leaves, yellowish or reddish translucent spots appear on the upper surface, which later darken and become necrotic, while a white sporulation develops on the lower surface. On older leaves, smaller lesions occur, typically in interveinal areas.

Shoots may show dark lesions, longitudinal cracks, and a characteristic “S-shaped” growth. Finally, sporulation and browning affect berries, with symptoms varying according to the developmental stage of the cluster.

Knowledge for effective management

The behavior of *P. viticola* has been extensively studied by plant pathologists. This has made it possible to understand the crucial importance of timely intervention against primary infections, which do not occur only at the beginning of the season but often continue through June and beyond. Proper management of primary infections simplifies vineyard protection against secondary infections, should they occur.

Prevention through sound agronomic practices

As with any other pathogen, downy mildew can also be effectively managed through prevention based on sound agronomic practices.

Proper canopy management, particularly leaf removal, is a key pillar in reducing the risk of disease development, due to its positive effect on cluster aeration. Continuous and careful monitoring of vineyards, starting from those at highest risk, is also essential as well as the use of efficient forecasting models, support timely interventions and therefore increase the likelihood of success of the crop protection strategy.

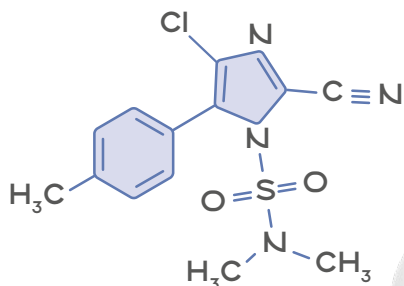
Finally, the type of plant protection equipment used and its correct calibration should not be underestimated.

Cyazofamid, a downy mildew active substance

Cyazofamid, one of the active substances widely used for the control of *P. viticola*, belongs to the chemical group of cyanoimidazoles. It acts on the cellular respiration of the oomycete by inhibiting the mitochondrial respiratory chain. Suitable for preventive use, cyazofamid exerts its activity on different stages of the pathogen. Thanks to its favorable octanol–water partition coefficient, it is able to bind to plant waxes, showing high resistance to wash-off.

Daramun for downy mildew control

Daramun is a suspension concentrate product based on cyazofamid, developed by Diachem for the control of oomycetes, and in particular downy mildews affecting wine and table grapes, potato, and tomato.



ACTIVE INGREDIENT

cyazofamid

CHEMICAL FAMILY

Cyanoimidazoles

MODE OF ACTION

Inhibits mitochondrial respiration (at the level of enzyme complex III), binding to the inner side at the Q site of the cytochrome bc₁ complex (Qil - quinone inside inhibitor site), thereby disrupting the electron transport chain (resulting in inhibition of ATP synthesis)



The finely micronized formulation is readily suspendable and easily dispersible, solvent-free, and compatible with numerous commercial products with complementary modes of action.

It is a preventive fungicide with high affinity for cuticular waxes and moderate penetration capacity.

These properties result in strong resistance to rain wash-off, even in the event of heavy rainfall after application, and partial redistribution within the treated canopy.

These characteristics are further enhanced by the presence of a specific organosilicon surfactant in the formulation, a next-generation wetting agent that maximizes adhesion and uniform coverage of the plant surface.

How to use Daramun

The numerous registration trials conducted in Italy and other European environments demonstrate high efficacy on both leaves and clusters. The specific properties of the formulation support its positioning for cluster protection, with preventive applications and in combination with products having different modes of action.

Daramun offers high flexibility in application timing and adaptability to different downy mildew control strategies. It also shows no negative effects on yeasts or fermentation.

Registration/import tolerance in numerous countries worldwide.

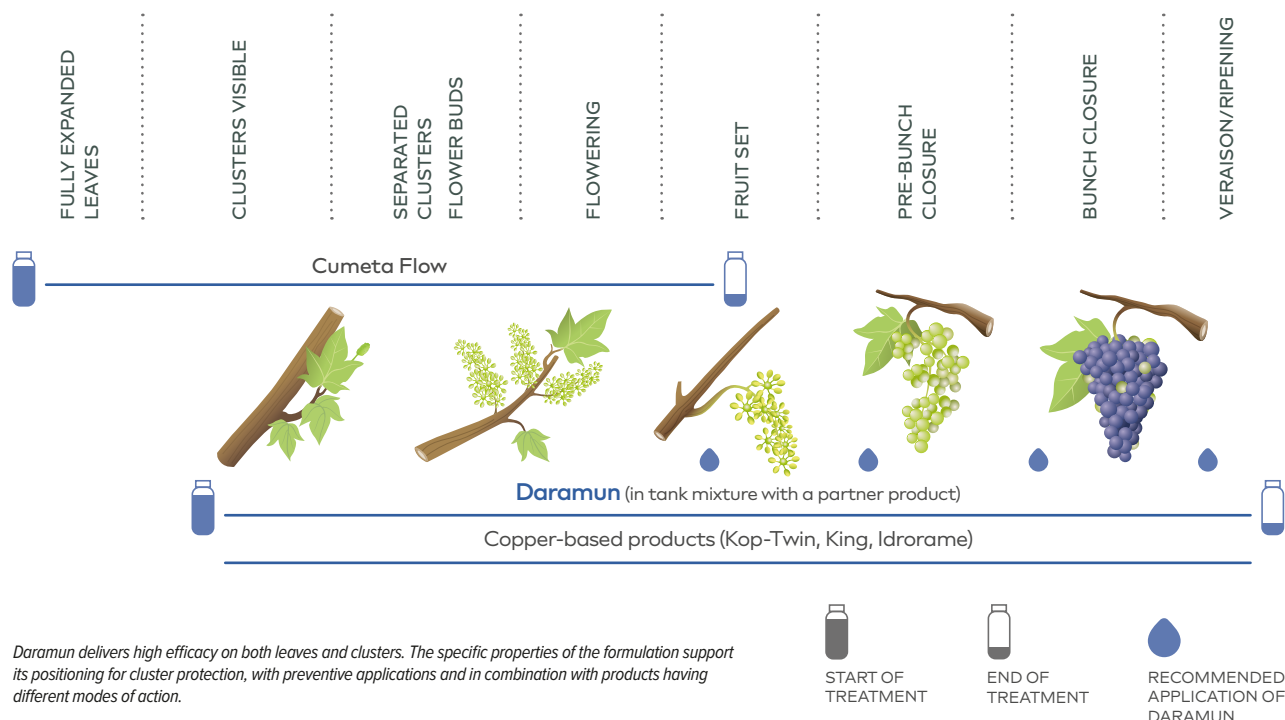
Resistance management prevention

The development of resistance to specific active substances is one of the main issues to be prevented in crop protection strategies, including grapevine.

This is even more critical in light of the progressive reduction in active substances authorized for use by the European Union and the expected decrease in pesticide use within the EU under the Farm to Fork strategy.

To manage the risk of resistance development to cyazofamid, the following measures are recommended:

- adjust treatment intervals according to weather conditions and disease pressure;



- › apply the product before infection events;
- › tank-mix with downy mildew fungicides with different modes of action;
- › use within a programme including products with different modes of action.

Cyazofamid does not show cross-resistance with active substances belonging to the QoI (Quinone Outside Inhibitors) group, which act on the outer mitochondrial membrane (e.g. azoxystrobin, pyraclostrobin, kresoxim-methyl).

COMPOSITION	Cyazofamid 9,5% (100 g/l)
REGISTRATION OF ITALIAN MINISTRY OF HEALTH	n° 16946 of 16.01.2020
HAZARD INDICATIONS	Danger  EUH401
FORMULATION	Suspension concentrated (SC)
CROPS (phi)	Grape (21 days), Potato (7 days), Tomato (field and greenhouse) (3 days)
DOSAGES AND N° OF TREATMENTS	Grape 0,9-1,1 l/ha (max 4 treatments), Tomato and Potato 0,8 l/ha (max 6 treatments)
PACKAGING	1 lt bottles (carton box 10 pcs) - 5 lt can (carton box 4 pcs)



For more information:

DARAMUN

Plant protection product authorized by the Ministry of Health based on cyazofamid (Reg. No. 16946 dated 16/01/2020). Use plant protection products with caution. Always read the label and product information before use. Pay attention to hazard statements.

High sensitivity of *Plasmopara viticola* to cyazofamid

Monitoring conducted between 2021 and 2023 in 37 vineyards. The collected data show a high level of sensitivity of downy mildew populations to cyazofamid, including in Northern regions

The management of grapevine downy mildew, caused by the oomycete *Plasmopara viticola*, is becoming increasingly complex. Effective disease control cannot be separated from proper resistance management and careful monitoring of pathogen population sensitivity profiles.

The adoption of anti-resistance strategies, based on the rotation and mixing of all available active substance classes, is essential to maintain the long-term efficacy of treatments.

This study presents the results of a three-year survey (2021–2023) conducted to evaluate the sensitivity to cyazofamid of 42 populations of *P. viticola* collected from 37 vineyards located mainly in Northern Italy.

Mode of action and resistance mechanism

Cyazofamid belongs to the Qil (Quinone inside Inhibitors) class of fungicides.

Its target is complex III of the electron transport chain, specifically the Qi site of the cytochrome bc₁ complex. Inhibition of this enzyme blocks mitochondrial respiration, preventing the production of energy required for pathogen growth.

The application of anti-resistance strategies is rec-

ommended for this chemical class. To this end, the maximum number of applications permitted on the label for cyazofamid is four, with a recommendation to limit to three treatments under integrated production guidelines and in areas with a high risk of resistance development.

The absence of observed cross-resistance with Qol fungicides (Quinone outside Inhibitors, FRAC 11) and QioSI (Quinone inside and outside inhibitors, stigmatellin binding mode, FRAC code 45) suggests that resistance management strategies may include the use of these fungicide classes.

Study objective

The objective of the study was to characterize the sensitivity profile of Italian populations of *P. viticola* to cyazofamid, in order to assess the effectiveness of anti-resistance strategies in limiting the spread of resistant individuals.

Unlike other assays conducted on sporangia during the growing season, this investigation focused on oospores, the overwintering structures of the pathogen, collected at the end of the grapevine vegetative season.

This methodological approach made it possible to:

- › assess the effect of selection pressure exerted by the disease control programme on the pathogen, in terms of the proportion of resistant individuals within the total population;
- › obtain an overview of the composition of the overwintering population, which will give rise to the inoculum for infections in subsequent seasons.

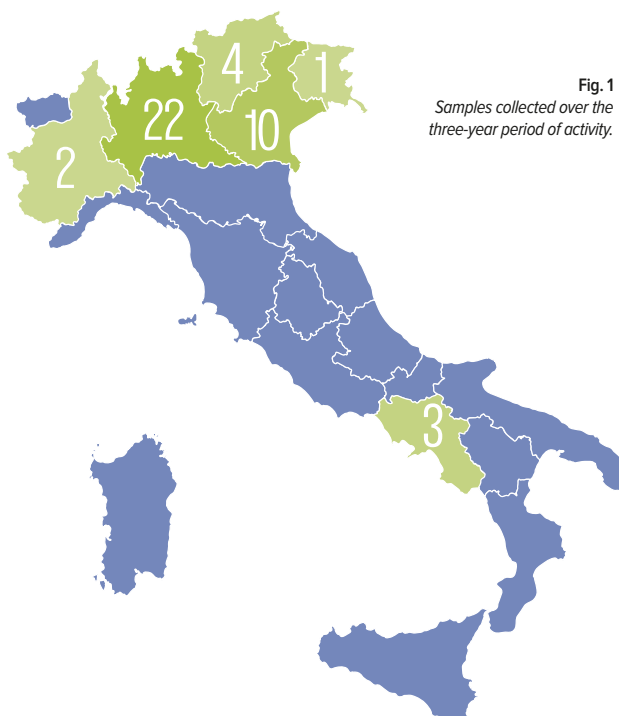
Monitoring methodology

Each year, between September and October, grapevine leaves showing downy mildew symptoms were randomly collected from commercial vineyards located in six Italian regions, mainly Lombardy and Veneto (*Fig. 1*). In February, oospores were isolated from leaf debris, suspended in sterile distilled water, counted, and inoculated onto an agar-water medium containing different concentrations of cyazofamid (0 to 400 mg/L). A total of 1,200 oospores per sample were examined. The plates were incubated in the dark at 20°C, and after 7, 10, and 14 days the number of germinated oospores was recorded.

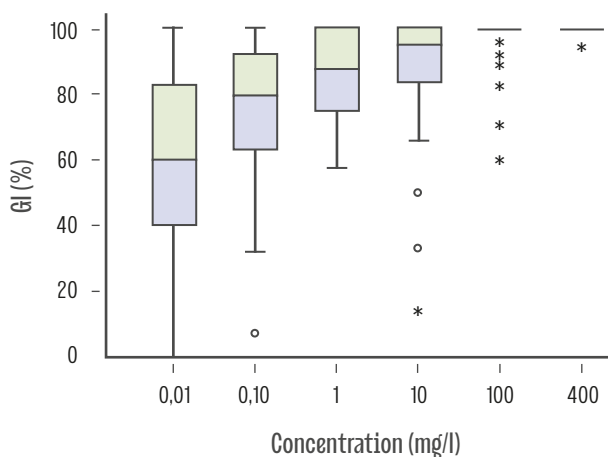
The data obtained were used to calculate the germination percentage (G) and the germination inhibition percentage (GI) relative to the control for each fungicide concentration. Based on these data, toxicological parameters useful for evaluating sensitivity to the fungicide were calculated, including the effective concentration inhibiting 50% of germination (EC_{50}) and the 95% effective concentration (EC_{95}) for germination inhibition, as well as the minimum inhibitory concentration (MIC) required to completely inhibit oospore germination).

Monitoring methodology

The results showed a high inhibition of oospore germination (GI) even at low cyazofamid concentrations, with values of around 60% at just 0.01 mg/L (*Graph 1*). Inhibition progressively increased with rising fungicide concentrations, reaching 100% from 100 mg/L onwards. Only in a very limited number of isolated cases were some oospores able to germinate at the highest fungicide concentrations (100 and 400 mg/L).



Where germination was observed at 100 mg/L, the inhibition percentage exceeded 80% and only in two cases ranged between 60% and 70%.



Graph. 1. Distribution represented by a box-and-whisker plot. Asterisks and circles indicate outliers. The line within the box represents the media; the whiskers extending from the box indicate the minimum and the maximum values.



Symptoms of Plasmopara viticola on grapevine leaves.

The analysis of the distribution of toxicological parameter values shows that most EC_{50} values fall within the range of 0.0001–0.06 mg/L.

The distribution of EC_{95} and MIC values does not follow a normal distribution and shows two distinct groups. In particular, it is possible to distinguish one group with EC_{95} values below 100 mg/L and a second group with values above this threshold. A similar separation is also observed for MIC values. Consequently, the 100 mg/L concentration is adopted as a discriminating threshold, capable of distinguishing between sensitivity and resistance for both EC_{95} and MIC.

Anti-resistance strategies as an effective tool

The monitoring results provide an overall positive picture regarding the sensitivity of the populations analysed. The rare cases of resistance, mainly detected in some vineyards in Lombardy in 2023, appear to result from the interaction between environmental factors and selection pressure exerted by the fungicide.

However, even in these situations, the majority of individuals were sensitive to cyazofamid, and only a small proportion was able to germinate at concentrations above 100 mg/L.

This indicates that the presence of resistant individuals, although detected, remains limited and can be effectively managed through appropriate anti-resistance strategies. In the few vineyards where germination inhibition was between 60% and 70%, further investigations will be required to define the most suitable management strategies.

In this context, continuous monitoring represents an essential tool for tracking the evolution of the situation and assessing the effectiveness of the implemented measures.

Overall, the collected data confirm a high level of sensitivity in *P. viticola* populations, even in northern areas, where downy mildew pressure is particularly intense and the risk of resistance is higher.

In addition, monitoring has enabled the precise identification of situations requiring closer attention, providing useful indications to prevent further spread of resistance.

Continuing monitoring activities and assessing mutations associated with resistance will make it possible to better estimate the dynamics of resistant genotypes throughout the growing season and to obtain essential information for optimizing grapevine protection strategies.



we embrace agriculture

For over 70 years, we have been an Italian, family-owned company evolving alongside agriculture. Our mission is to create sustainable solutions for today's and tomorrow's agriculture. For this reason, we support farmers in their daily challenges, promoting more productive crops while respecting nature, and contributing to food security through continuous investment in research and innovation.

Improving and growing stronger, together, every day.



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