

PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVIII cycle, 2022-25)

Project draft

1. Field of interest

Plant pathology

2. Project title

The management of grapevine downy-mildew treatments for a sustainable viticulture: from fungicide resistance to disease forecasting models

3. Tutor: Silvia Laura Toffolatti

4. Relevance of the topic and state of the art:

Viticulture records the strongest use of plant protection products¹. In particular, the control of downy mildew is mainly based on the intensive use of fungicides which, in addition to pose risks to human health and the environment, can lead to the onset of fungicide resistance in the pathogen population². The use of forecasting models represents one of the most promising strategies aimed at rationalizing the disease management in the vineyard^{3,4} and allows, on average, to halve the number of treatments, ensuring an adequate protection of the crop⁵. Information on the use of forecasting models related to resistance to fungicides in *Plasmopara viticola* (agent of grapevine downy mildew) are not present⁶. This research topic aims to lay the foundations for the development of a new solution for management of grapevine downy mildew in the open field. A disease forecasting model (EPI) will be used to identify the right timing to apply the fungicide treatment and fungicide resistance will be monitored to choose the most suitable active substances. This will allow the personalization of the intervention strategy by providing support for an optimized defense approach, in accordance with European programmatic policies (Green Deal and Farm to Fork Strategies).

5. Layout of the project (draft)

The project will be articulated in five main work packages (WP).

- WP1. Field trials.
- WP2. Simulation of the grapevine downy mildew epidemics with EPI.
- WP3. Assessment of fungicide sensitivity.
- WP 4. Evaluation of the efficacy of the disease management strategy.
- WP5. Data analysis, scientific paper(s) and thesis writing.

5.1. Materials & Methods:

- WP1. Selection of the fields will be performed according to the history of the downy mildew epidemics. Different fields will be selected on the basis of the disease pressure (high-medium-low). At least 2 vineyards will be selected per scenario. Two plots consisting of four replicates of 20 plants will be established. The first one will not be treated with fungicides, the second one will be treated with the selected

fungicides according to the indications of the model (WP2). The rest of the vineyard will be treated according to the farmer’s strategy. The protocols for the grapevine downy mildew management in vineyard will be defined according to anti-resistance strategies and information on the fungicide sensitivity of the population (if available). Infected leaves will be sampled for fungicide resistance assessment in WP3. Disease intensity (incidence and severity) will be periodically assessed in each vineyard to assess the real disease epidemics.

- WP2. Simulation of the grapevine downy mildew epidemics with EPI in the selected fields to provide indications for the application of the fungicides selected in WP1. Bulletins with the indications of the model will be provided twice a week to the technicians involved in the study that will perform the treatments with the fungicides selected in WP1 according to the infection risk signaled by the model.
- WP3. Design and application of phenotyping tools to assess fungicide sensitivity at the lab level. Biological and molecular methods for the detection and quantification of fungicide resistant strains within the pathogen population will be used for each mechanism of resistance.
- WP 4. Evaluation of the efficacy of the disease management strategy. The results of the simulations with EPI will be compared with the real epidemics. Furthermore, the efficacy of the disease management achieved according to our experimental activity (EPI strategy) will be assessed by comparing the disease intensity obtained in the untreated plot and according to the farmer’s strategy (conventional disease management).
- WP5. Data analysis, scientific paper(s) and thesis writing. An extensive literature search will be needed for the set up of the experiments and data analysis.

5.2. Schedule and major steps (3 years):

The schedule of the project, starting from October 2022, is visible in Figure 1. WP1 activities will be carried out at the start of the project to select and plan the field trials, that will take place in spring-beginning of summer of the three years. Field trials will be performed for three consecutive years to maximize the reliability of the data. WP2 activities will be performed during grapevine growing seasons for the three years. WP3 activities will take place early at the start of the project, to select the phenotyping tools that will be used in autumn-winter. WP4 will take place in winter, and WP5 at the end of the project.

Figure 1. Gantt chart showing the schedule of the project.

ACTIVITY	MONTHS (starting from October 2022)																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WP1	█										█												█													
WP2	█						█						█						█						█						█					
WP3	█						█						█						█						█						█					
WP4	█												█												█											
WP5	█																								█											

6. Available funds

CTE_INT21STOFF_01, 6,800 euro

6. Literature:

1 Commission E. *The use of plant protection products in the European Union Data 1992-2003*

2007 edition. 2007.

- 2 Gessler C, Pertot I, Perazzolli M. *Plasmopara viticola*: A review of knowledge on downy mildew of grapevine and effective disease management. *Phytopathol Mediterr* 2011; **50**: 3–44.
- 3 Shaw MW. Preparing for changes in plant disease due to climate change. *Plant Prot Sci* 2009; **45**: 3–10.
- 4 Pertot I, Caffi T, Rossi V *et al.* A critical review of plant protection tools for reducing pesticide use on grapevine and new perspectives for the implementation of IPM in viticulture. *Crop Prot* 2017; **97**: 70–84.
- 5 Toffolatti SL, Ciampitti M, Salvetti M, Bianco PA. Impiego del modello EPI-peronospora per un uso sostenibile dei fungicidi. 2016; : 20–23.
- 6 Massi F, Torriani SFF, Borghi L, Toffolatti SL. Fungicide resistance evolution and detection in plant pathogens: *Plasmopara viticola* as a case study. *Microorganisms* 2021; **9**: 119.