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COPPEREPLACE 1. Copper application in organic viticulture represents a real challenge today. Part 1 - Scientific Activities

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In grape and wine production, one of the main relevant and recurrent diseases is downy mildew, caused by the fungus *Plamospara viticola*. It is frequently present in wine production worldwide, with a significant high annual incidence in some regions. Since the discovery of Bordeaux mixture (copper sulphate and lime) in the 1880's, many formulations based on copper (Cu) have been developed and used in viticulture production.

➥ https://coppereplace.com/

Introduction

Cu soil pollution arose mostly from its indiscriminate use against downy mildew on vulnerable soils during the second half of the 20th century. Cu is an essential element for plant growth, being naturally present in soil, usually at low concentrations (5–30 mg/kg); however, due to the continued use of Cu-based fungicides, a significant increment of Cu levels has been observed in many European soils[1]. The increase in Cu concentrations in soils can impact negatively and at different levels soil accumulation, soil microbiota, overall biodiversity and ecosystem functioning, together with other pesticides; this has led to specific regulations being applied in populated areas near vineyards[2], creating a major challenge for farmers today.

The use of Cu in organic production has been restricted since 2002[3] [4], particularly affecting more than other production modes (i.e. integrated production, IPM), because they can alternate Cu with another alternative products. Additionally, the complex processes of registration and authorisation for new plant protection products (PPP) represent hurdles with economic impacts.

The use of alternative products to Cu is thus being requested in many countries, but to varying degrees of success, causing limitations and affecting strategies in viticulture[5].

Working packages, activities and some results

COPPEREPLACE was a research project funded by the Interreg SUDOE Programme and formed by 13 Spanish, French and Portuguese multi-actor partners. The overall aim of the project was to develop and comprehensively implement new technologies, products and strategies in order to limit or replace the use of Cu, and thus reduce its application in vineyards while remediating contaminated soils in the SUDOE region. Six Work Packages (WPs) were developed in the project. In this first article, we will provide the scope and results of the first three: (WP1) alternatives to Cu, (WP2) impact on vulnerable soils and (WP3) optimisation of Cu dosage (Figure 1).

WP1 aimed to identify alternative solutions to help reduce Cu use in downy mildew infection control. Some of the selected alternative products were already on the market and registered as fungicides or fertilisers, while others were in the development phase in the PPP sector. The objective of the project's experimental trials was to combine alternative products with a reduced dose of copper. Trials were conducted in three geographical areas, and two production modes (integrated and organic) were applied in different-sized plots: three small trials in micro-parcels (IFV, SOGRAPE) to screen 11 selected products; one medium trial (TORRES) to evaluate some selected products in a larger plot; and finally, three large trials (GERARD BETRAND, SVBNA, SOGRAPE) in collaboration with winegrowers under real-world conditions. All the experiments were conducted in randomised controlled trials, including non-treated controls to evaluate local pathogen pressure over two years. During this period, low downy mildew pressure and hail damage disrupted some trials. Nevertheless, having trial sites in three different countries helped obtain usable results. Interesting results concerning several yet non-registered products (sprayed separately from copper) based on plants or algae extracts were observed in small trials, but further research on this is required. A Cu-based fertiliser (Cu-heptagluconate) showed promising and consistently good results (similar efficiency to control treatment), decreasing the total amount of Cu applied when downy mildew pressure was moderate. With the regulation of fertiliser use becoming stricter, it would be of interest to present these results to the EC for policy-making purposes. Further research in large trials is required and under more intense downy mildew pressure levels to provide robust results when assessing these alternatives.

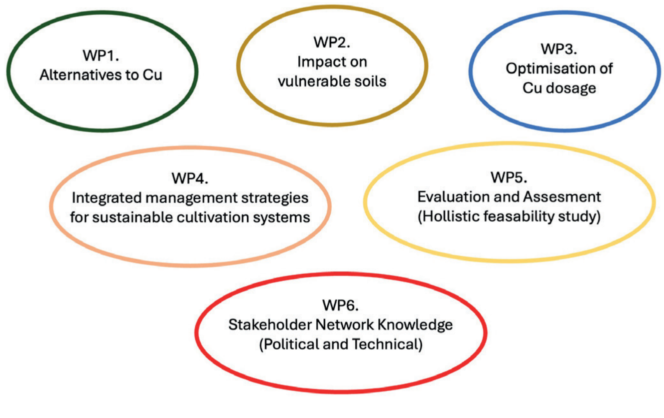

FIGURE 1. COPPEREPLACE Working Plan (work packages included in the project).

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None of these regulations consider the properties of vineyard soils, which can modulate Cu availability in the soil. Therefore, the aims of WP2 included unveiling the role of pH and soil organic matter (SOM) in the identification of the most Cu-vulnerable vineyard soils. Soils from ten different vineyards (different range of pH and SOM contents) were spiked and tested for their toxicity to a variety of soil and aquatic species. The vulnerability of the soils to Cu contamination and its level of toxicity depended mostly on two factors: Cu accumulation and soil properties. Soils with low (acidic) pH and organic matter (OM) content were the most vulnerable to the same Cu level. Soil vulnerability depended on three soil physicochemical properties: total Cu content, soil pH, and OM. Generally, when Cu soil level is below 100 mg/kg, the impact on surrounding waters, terrestrial and aquatic organisms is low. If the Cu level is above 100 mg/kg and soil pH below 5.0, negative effects on soil biodiversity and functions can occur. With very acidic soils (pH 5.0–6.0), special attention and strict soil monitoring is required. At soil pHs of above 6.0, less Cu impacts are to be expected. When Cu levels exceed 100 mg/kg, earthworm survival must be closely monitored, because they are likely the most vulnerable tested organisms in vineyard soils.

WP2 also produced policy-making guidelines for the identification of the most vulnerable soils, Cu application limits and the implementation of remediation strategies. General recommendations were included; for example, specifications were given regarding active substance doses and application frequency, soil management practices (such as adding calcium carbonate in the form of, for instance, milled mussel shells) for increasing soil pH, or incorporating a source of OM (such as milled pine bark for absorbing Cu ions), and the assessment soils of that integrates both biological and physicochemical indicators. These guidelines have been shown to effectively improve soil properties, reducing Cu bioavailability and toxicity, or reducing the negative impacts of Cu accumulation on organisms and the environment. However, the effectiveness of these rehabilitation alternatives depends on the soil type and properties and a preliminary evaluation of the site and soil should thus be mandatory.

WP3 aimed to develop and implement innovative precision techniques for better adjustment of Cu dosage, thus reducing dispersion and negative impacts on the environment. A tailored strategy application (Dosaviña®[6]) was implemented to determine the optimum application volume for phytosanitary treatments in vineyards based on the structural characteristics of the vegetation and type of equipment used.

Variable rate application of PPP based on canopy vigour maps was studied to adjust the right application volume according to leaf area, which varied depending on several factors (vigour zones, phenology, slope, soil water reserves, etc.). Using satellite images, a vigour map was created and the appropriate application volumes for each vigour zone were adjusted using the Dosaviña® application. By means of an intelligent PPP control system application (WAATIC), we reduced the amount of applied volume (8–42%) relative to the fixed rate application. In parallel, significant Cu reductions were recorded for variable applications (20–60%) instead of fixed rate, with the same biological efficacy against downy mildew between treatments.

Finally, a European Patent Application[7] for a new microencapsulated Cu product (based on $CuSO_4$ at different concentrations, with non-toxic or contaminant polymeric materials) was registered. Studies showed a higher Cu deposition on filter papers and wine leaves[8], which may reduce the levels of Cu cations needed (25%) for sufficient crop protection.

WP3 results indicated that the integrated use of these new technologies could support farmers in meeting the European Union Cu reduction targets required y current regulations. ■

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1 Ballabio, C., Panagos, P., Lugato, E., Huang, J. H., Orgiazzi, A., Jones, A., & Montanarella, L. (2018). Cu distribution in European topsoils: An assessment based on LUCAS soil survey. *Science of The Total Environment, 636*, 282-298. https://doi.org/10.1016/j.scitotenv.2018.04.268

2 https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000039686039

3 Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products. *Journal Officiel de l'Union Européenne.*

4 REGULATION (EU) 2018/1981 of 13 December 2018. *Journal Officiel de l'Union Européenne.*

5 De la Fuente, M., Fernandez-Calvino, D., Tylkowski, B., Montornes, J.M., Olkiewics, M., Pereira, R., Cachada, A., Caffi, T., Fedele, G., & De Herralde, F. (2021). Alternatives to Cu applications in viticulture. How R&D projects can provide applied solutions, helping to establish legislation limits. In: *IntechOpen eBooks.* https://doi.org/10.5772/intechopen.100500

6 Dosaviña®. Polytechnic University of Catalonia. https://dosavina.upc.edu/

7 Tylkowski, B., et al. 2021. *European Patent Application EP21382965.8.* Authors: Fundation EURECAT and Polytechnic University of Catalonia.

8 Ortega, P., Sánchez, E., Montornés, J. M., Tylkowski, B., Olkiewicz, M., & Gil, E. (2023). Design and evaluation of microencapsulation technology to reduce the environmental impact of copper fungicides in vineyards. *Crop Protection, 176*, 106502. https://doi.org/10.1016/j.cropro.2023.106502