COPPEREPLACE project SOE4/P1/E1000
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Summary of results of the "COPPEREPLACE" project - 2023 edition

Research into strategies to reduce the use of copper in organic viticulture

This document is a summary of the full report presenting the project results. For more information, don't hesitate to get in touch with Vignerons Bio Nouvelle-Aquitaine.

The utility of copper in organic viticulture

According to the INRAe report "Can organic farming manage without copper?"[1], **copper is the only tool that is sufficiently effective against downy mildew *(Plasmopara viticola)* in organic farming.** Currently, its use is essential to ensure a satisfactory yield, especially in organic vineyards located in maritime climates, where the pressure from downy mildew is extremely high. Copper also has a role to play in conventional viticulture, as most systemic products must be combined with a contact product to be effective (copper being one of the last contact products still authorised). In addition, it is one of the few active ingredients to which downy mildew has not developed resistance.

Why does copper pose a problem?

Nevertheless, the use of copper raises many issues[2]. **It is a heavy metal that does not decompose in the soil: its use is not without consequences for the environment.** While the doses used have dropped considerably (reduced tenfold since the 1960s), copper has accumulated and continues to accumulate in the top layers of the soil (to a depth of approximately 10 cm). Some of our vineyards thus have a high concentration of copper, well above the natural level in the soil. **Too much of this metal in the soil can lead to phytotoxicity problems.**

Political background to copper use

As a result, the use of copper is being strongly challenged by various national and European bodies, with the aim of pushing for its reduction or even a total ban. Since 2015, copper compounds have been included in the European list of candidates for substitution, mainly because copper is not degradable and it accumulates in the soil. It will have to undergo a re-approval assessment every 7 years, as opposed to 15 years previously, with the next to take place in 2025. Increasing restrictions on permitted copper doses (down from 6 to 4 kg/ha/year, smoothed over 7 years in the latest re-approval in 2018), as well as the threat of a total European ban, are causing difficulties for producers. This is especially true for organic winegrowers, who cannot use synthetic pesticides. **As a result, there is a huge demand for research to come up with reliable alternatives.** It is in this context that the Coppereplace project was set up.

The Coppereplace project and its goals

Coppereplace is a European project funded by the Interreg Sudoe programme, which promotes transnational cooperation to address issues common to the regions of south-west Europe in France, Spain and Portugal. Running from November 2020 to February 2023, the project brings together 13 public and private partners from the wine sector in these 3 countries. **The goal of Coppereplace is to find technically and economically viable solutions to reduce the use of copper in our vineyards and its environmental impact.** The project is structured around the following themes:

- Theme 1: Testing alternative products or those that reduce the use of copper;
- Theme 2: Categorising copper-contaminated soils and searching for clean-up solutions;
- Theme 3: Developing new strategies to optimise spraying;

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[1] *INRAe, Summary of the scientific assessment report "Can organic farming manage without copper?", June 2018 - https://www.inrae.fr/sites/default/files/pdf/expertise-cuivre-en-ab-8-pages-anglais-1.pdf*

[2] *Vinopôle Bordeaux Aquitaine "Mémo Cuivre en Viticulture" (Memo on copper in viticulture), May 2022*

- Theme 4: Testing a large-plot protocol combining the leads of interest from the other themes;
- Theme 5: Assessing the economic, social and environmental impact of copper-reduction solutions;
- Theme 6: Developing a European expert network on copper reduction in viticulture.

Leads for copper reduction, but no alternatives

A selection has been made of alternative products or those that reduce the use of copper. This selection has been made according to the applicability and innovation maturity of the products.

No. of the product tested	Product name	Company	Active ingredient	Category	Recommended dose	Laboratory test (2022)	Micro-plot test	Large-plot test
1	GLUCOSEI	SEIPASA (Spain)	Copper heptagluconate 8% w/w	Basic substance	3 L/ha	IFV (Nîmes)	IFV (Bordeaux, Nîmes) Sogrape	VBNA Château l'Hospitalet Sogrape
2	SALIX	BIOVITIS (France)	Salix cortex 74 g/l	Basic substance	5 L/ha	IFV (Nîmes)	IFV (Bordeaux, Nîmes) Sogrape	VBNA Château l'Hospitalet Sogrape
3	EQUISET	ASCENZA	Equisetum 2 g/l	Basic substance	2 L/ha	IFV (Nîmes) IFV (Bordeaux)	IFV (Bordeaux, Nîmes) Sogrape	VBNA Château l'Hospitalet Sogrape
4	ALFOSITOL	FUTURECO (Spain)	Copper 2.6% w/w, P_2O_5 23% w/w, K_2O 20% w/w	Fertiliser	1.5 to 2.25 L/ha	-	Sogrape	-
5	FOSFIMAX	FUTURECO (Spain)	P_2O_5 20% w/w, Zn 5% w/w	Fertiliser	150 ml/hl	-	Sogrape	-
6	Not for publication		Concentrated extract of symbiotic plants	-	14 L/ha	IFV (Nîmes) IFV (Bordeaux)	IFV (Bordeaux, Nîmes)	-
7	Not for publication		Microalgae 5 g/L	-	500 g/ha	IFV (Nîmes) IFV (Bordeaux)	IFV (Bordeaux, Nîmes) Sogrape	-
8	Not for publication		Plant infusion	-	4000 g/ha	IFV (Nîmes) IFV (Bordeaux)	IFV (Bordeaux, Nîmes)	-
9	Not for publication		Plant extract	-	0.2 L/ha	IFV (Nîmes) IFV (Bordeaux)	IFV (Bordeaux, Nîmes) Sogrape	-
10	LIMOCIDE	VIVAGRO	Orange essential oil	Crop protection product	0.8% (1.6 L/ha max.)	-	IFV Bordeaux	VBNA Château l'Hospitalet Sogrape
11	BELVINE	CERIENCE	325.6 g/L of ABE-IT 56 (components of *Saccharomyces cerevisiae* lysate)	Plant defence stimulator	3 L/ha	IFV (Nîmes) IFV (Bordeaux)	IFV Nîmes	-

These products were used in trials conducted over one or two years within the three partner countries and on three different scales:

- **Laboratory scale:** the goal was to obtain more information on the effectiveness of the products on their own, without the influence of weather conditions on the ground. It was thus possible to assess "alternative" products alone, by inoculating treated leaves with downy mildew.
In the two trials carried out at IFV Nîmes, three products seemed to be effective against downy mildew: Glucosei, product 7 and product 9. Only Glucosei, in both trials, showed greater effectiveness than copper.
The three trials carried out in Bordeaux did not lead to the same conclusions. **Only treatment with copper showed positive results.** This may be explained by later inoculation with the fungus after treatment, thus limiting the effectiveness of the products tested.

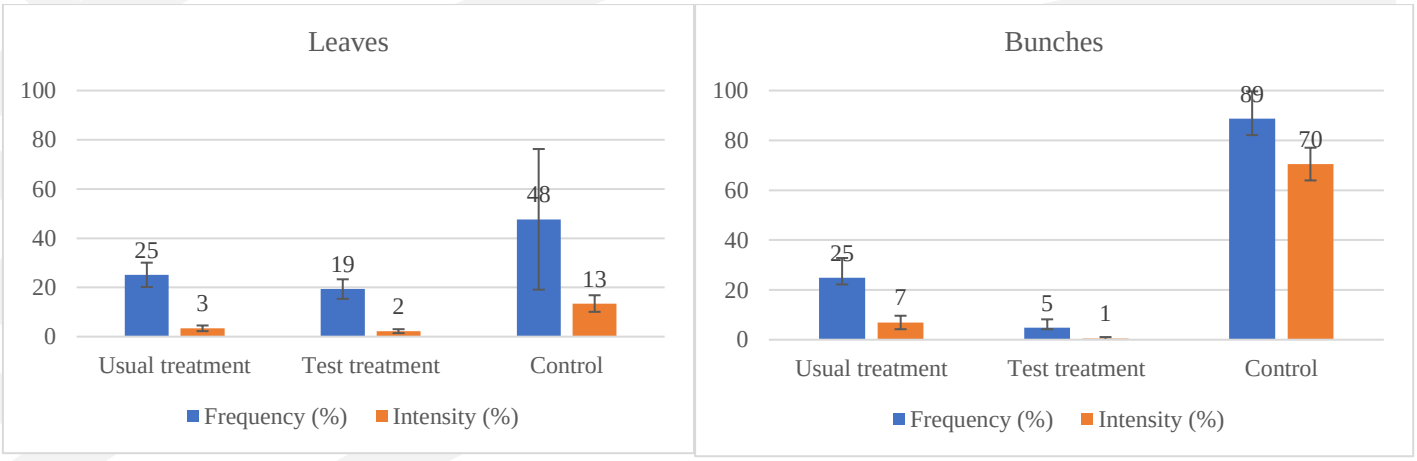
- **Micro-plot scale:** the goal was to test a large number of products on small plots of 10 vines, repeated 4 or 5 times.
The trials in Nîmes did not show significant differences, but quite positive trends for product 6 and Glucosei. Product 7 also showed better results when used alone rather than in combination with copper.
The trials in Bordeaux also showed positive trends for product 6 (as in Nîmes), product 8 and, to a lesser extent, Glucosei.

For the trials in Portugal (Viseu) there was only a very low level of downy mildew. Nevertheless, some products seemed to show a synergistic effect: product 9, Equiset, Salix and Glucosei. **A threefold reduction in the copper dose provided similar protection to that of a full dose of copper on its own.**

- Large-plot scale: the goal was to test some of the products already assessed in the micro-plot trials under "real life" conditions. Only products with a marketing authorisation (MA), or permitted for use as a defence stimulator or foliar fertiliser, could be tested.
The results of the trials in Bordeaux showed that when the level of downy mildew was very high, as was the case in 2021, the untreated controls were devastated. Statistical tests show that full-dose copper provided better true protection. **The alternative products tested (Salix and Equisetum) were no more effective than the reduced dose of copper alone.** It is interesting to note the difference between the full and reduced dose of copper, which is not as pronounced as would be expected at such a high level of downy mildew.
In Bordeaux in 2022, the downy mildew was more manageable than in the previous year. **Half-dose copper protection was almost as effective as the full dose, demonstrating the value of proper positioning of treatments. In one out of two estates, Glucosei alone gave good protection results, comparable to full-dose copper.**

Theme 4 allowed comparison between an **estate's usual treatment** and a **suggested programme to reduce the copper dose by using the products tested in theme 1.** In this programme, a conventional copper product was used in combination with Glucosei. Sweet orange essential oil was also added. Only the Bordeaux trial showed downy mildew. **At the end of June, significantly better bunch protection was shown under the test programme compared with the estate's conventional treatment (and the untreated control). This was demonstrated in terms of the frequency and intensity of downy mildew.** While there was no significant difference on the leaf, the same trend was observed. Later observations could not be used, due to hail.

Frequency and intensity of downy mildew on the leaf and on the bunch – Château 3 - Bordeaux – 27/06/2022



These trials confirm the benefit of using a form of copper with another preparation. This improves its effectiveness at lower doses and reduces its concentration in the leaves.
The problem with Glucosei is that it is a copper-based product and hence does not meet the criterion for a copper replacement. It nevertheless seems to allow a reduction in the dose needed to obtain proper protection.
Its other limitation is that it is a foliar fertiliser, and hence cannot be used for crop protection purposes. This is especially the case in organic farming, where the use of foliar fertilisers has to be justified.
The last difficulty is related to obtaining supplies in France, doubtless due to the factors mentioned above. These circumstances further limit the possibility of using Glucosei in organic viticulture.
It should be noted that Glucosei was combined with copper and Limocide in this trial. Hence, Limocide may also have contributed to the observed effectiveness.

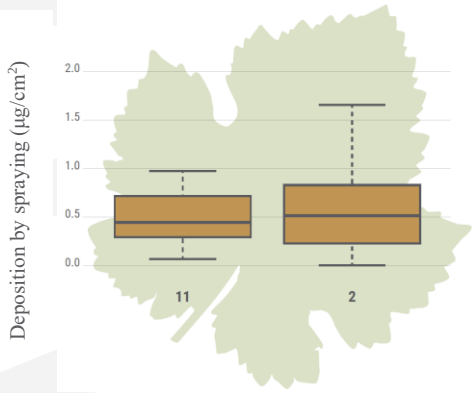
Micro-encapsulation of copper: an innovative lead?

Encapsulation in biopolymer matrices has been recognised as an effective method for controlled release of a bioactive agent used for plant protection. **The release of copper cations from micro-capsules and their prolonged presence on the leaves can lead to a reduction in the levels needed for effective crop protection.**

A micro-encapsulated product has been developed by EURECAT, a partner company in the project. In February 2021, an experiment carried out at the UPC compared four different micro-capsule formulations. **The results showed that copper deposition was 30-40% higher using the four micro-capsule formulations than by conventional application.**

In trials carried out from April to September 2021 at IFV Blanquefort, the deposition from micro-capsules (protocol 11) at a copper concentration of 1 g/L of Cu^{2+} ions was compared that of a conventional product (protocol 2).

Deposition of copper on the leaves by micro-capsule (protocol 11) and by conventional copper (protocol 2) during the 2021 trials.



However, the observations in terms of the frequency and intensity of downy mildew were less encouraging. **The biological effectiveness of low-dose copper and micro-capsules seems identical, but lower than that of full-dose copper.** However, the standard deviations are very high due to very different levels of downy mildew between the observation plots in the vineyard. **It cannot be concluded whether this lack of difference was because micro-encapsulation is ineffective or because the product was leached out by the heavy rainfall in June 2021.** The 2022 trials did not provide further information, as the trial plot was hit by hail. In addition, the copper was mixed with sulphur to control powdery mildew, which may have affected the condition of the micro-capsules. EURECAT is currently working on the effect of sulphur on the stability of the micro-capsules.

Even though the 2021 and 2022 trials were not conclusive, work on micro-encapsulation seems to be a worthwhile lead. Tests on application rate seem to point towards a possible reduction in the copper doses used. **This method paves the way for the development of new processes for the formulation of active ingredients.**

What to take away from Coppereplace

First of all, the COPPEREPLACE project has confirmed the great difference that can exist between wine-growing regions, and more specifically in south-west Europe in our case. These differences are reflected in the **impact of copper depending on the soil type** and **the pressure from downy mildew**. Only the Bordeaux region suffered from severe downy mildew attacks during the two years of trials. Portugal, Spain and south-east France were not affected by the fungus. The objectives differ as a result. On the one hand, there are regions that need protection at one or two key moments during the season. And, on the other hand, regions where the pressure remains strong and constant throughout the season (and notably with episodes of intense leaching).

Weather events such as frost or hail have also shown their importance. In addition to their dramatic consequences on yield, these events severely weaken the vine and extend the growth cycle, particularly the flowering stage, making the plant more vulnerable and encouraging the growth of downy mildew.

The management of leaching during key periods such as flowering is undoubtedly one of the most important factors that should guide the development of copper substitutes.

Not surprisingly, the **quality of spraying and the positioning of the products** at the right time remain decisive factors in achieving a reduction in copper use. This was made particularly clear from the half-dose protocol, for which the results were not that catastrophic.

It is not surprising that this project did not find a miracle solution to replace copper. Nevertheless, it has led to progress on several fronts.
A large number of products were tested, confirming that some are of little interest and others need to be improved. One of the key conclusions of the project, confirmed by themes 1, 3 and 4, is the importance of the **formulation of the products** in providing a reduction in the copper dose for the same level of effectiveness.

A major challenge in progress towards copper reduction was also highlighted: **the impossibility of large-scale testing of new products of interest that have not yet obtained authorisation.** None of the innovative products in theme 1 could be tested at large-plot scale due to the difficulties in obtaining waivers in France and Europe (except on condition that the entire harvest is destroyed). For organic viticulture, this is compounded by the automatic declassification of the harvest if an unlisted input is used.

The micro-encapsulation technique is promising, but will require further development to improve its effectiveness.
Coppereplace has thus reaffirmed the **importance of the formulation** of the products. The trials have shown how a better-formulated copper product can provide useful protection at a reduced dose.

In conclusion, **we cannot do without copper for the moment.** However, this does not prevent working on interesting leads for reducing its use through **discussions between researchers and professionals**.

The best tool for this will be the continued work and expansion of the **European network** set up through Coppereplace (theme 6). It should also be a forum for discussion with **public authorities and policy makers**, so that they have a clear view of progress on the subject and can **best adapt regulatory changes**.

Finally, once the solutions for reducing the use of copper have been technically consolidated, there will be a need to promote their use and to work on their cost and on the added value they can bring to winegrowers.

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