# Impact of **copper-based fungicide** and copper accumulation on soil **microbial biomass** abundance and activity in **cultivated soils**

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## Introduction

Copper-based fungicides are among the oldest fungicides used in agriculture, with **Bordeaux mixture** in particular. Their use was developed from the end of the 19th century.

Being part of the mineral fungicides, these products can be used in organic agriculture and are more generally used on a large scale to fight against plant diseases such as **potato blight** (*Phytophthora infestans*) or **grapevine downy mildew** (*Plasmopara viticola*). Easily leachable products, they require repeated applications, and can lead to a significant rise in copper levels in soils by accumulation. This is particularly the case for perennial crops remaining in place on the same agricultural plot for several decades, such as vines or orchards. Their use is now regulated within the European Union by Regulation (EU) N°2018/1981 authorizing a maximum of 28 kg Cu/ha over a period of 7 years (i.e. an average of 4 kg/ha/year) .

## Methods

The study aims at evaluating the impact of increasing doses of copper (from 0 to 1000 mg/kg soil, ***figure 1***), on the biological activity of three soils of contrasting nature and history: (i) a **clay-limestone** soil (pH = 8.2) having a viticultural history of more than 20 years, (ii) a **neutral loamy** soil (pH = 7.4) and (iii) an **acidic sandy** soil (pH = 6.0) recently conducted in viticulture. The different soils are treated and incubated under optimal standardized conditions for the development of soil microorganisms (temperature, humidity) over a period of 28 days (***figure 2***). The measurements concern the kinetics of the overall **respiratory activity** of soil microorganisms, as well as the abundance of these microorganisms in the soil (**living microbial biomass**) measured by fumigation-extraction with chloroform.

**Figure 1 : copper mixtures used in the experiment for soil contamination.** The fungicide mixture was prepared on with copper oxychloride and was deposited drop by drop on the soil samples.

| Mixture concentration (mg Cu/l) | 0 | 10 | 151 | 850 | 1700 | 8500 | 17000 |
|---|---|---|---|---|---|---|---|
| Cu applied to soil samples (mg Cu/kg dry soil) | 0 | 0.6 | 8.9 | 50 | 100 | 500 | 1000 |
| **Equivalent(*) per hectare (kg Cu/ha)** | **0** | **0.4** | **6** | **34** | **68** | **338** | **675** |

*Note: European regulation (EU) 2018/1981 in application since January 1, 2019 only authorizes maximum copper applications in agriculture at the rate of 28 kg of Cu per hectare over a period of 7 years.*
*(*) on the basis of an incorporation of Cu in the superficial topsoil (0-5cm).*

**Figure 2 : experimental units for measurement of soil biological activity by respirometry.** 40g of fresh soil are placed in an airtight jar with a $CO_2$ trap containing NaOH. For each soil type, three replicates are carried out for each concentration.

## Results

The results highlight the importance of the soil nature and its cultural history on the variability of the response of soil biological activity indicators to increasing doses of copper applied to the soil in the form of copper-based fungicide mixture (copper oxychloride). The clay-limestone soil shows the most important global biological activity, followed by the loamy soil and finally the sandy soil (***figure 3***). Whatever the soil, the effects of copper are only significantly perceptible from 100 mg Cu/kg of dry soil (i.e. more than 68 kg Cu/ha).

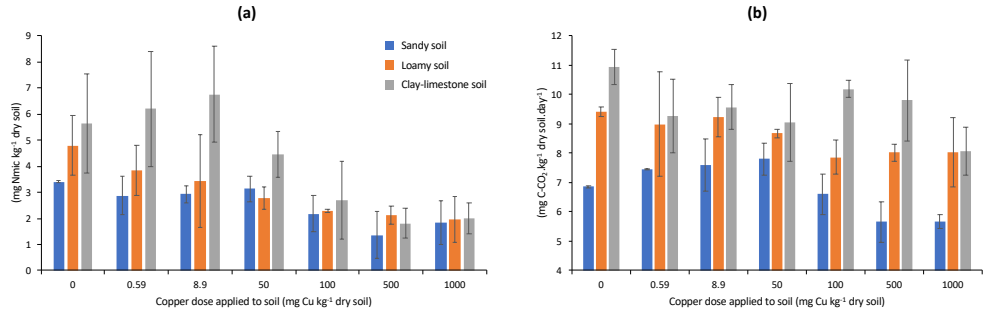


**Figure 3 : impact of increasing application doses of copper mixture on the living microbial biomass of soils (a) and on their respiratory activity (b).** The living microbial biomass of the soils was measured according to the ISO 14240 standard and the respiratory activity according to the FD U44-163 standard. For each dose of copper and each type of soil, 3 repetitions were carried out (i.e. a total of 63 samples).

## Conclusions

This study showed a negative effect on the biological activity of soils when Cu concentration raised **100 mg Cu/kg** of dry soil (i.e. approximately **68 kg Cu/ha in the 0-5 cm topsoil horizon**). This dose is well above the maximum dose authorized by European regulations over a period of 7 years. However, its gradual accumulation over the years deserves to be monitored, as well as the evolution of soil biological activity (key parameter of soil fertility). The sparing use of copper in the fight against plant diseases should be encouraged.

## References


- Commission Implementing Regulation (EU) 2018/1981 of 13 December 2018 renewing the approval of the active substances copper compounds, as candidates for substitution, in accordance with Regulation (EC) N° 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market, and amending the Annex to Commission Implementing Regulation (EU) N° 540/2011
- FD U44-163 (AFNOR). Soil improvers and growing media - Characterization of organic matter by potential mineralization of carbon and nitrogen. Standard procedure used for measuring soil biological activity by respirometry.
- ISO 14240-2. Soil quality — Determination of soil microbial biomass — Part 2: Fumigation-extraction method.


The experiments were carried out at Haute Ecole provinciale de Hainaut Condorcet – Département Agrobiosciences et Chimie – 11, rue Paul Pastur – 7800 Ath (BE)
**It is possible to have your soil samples analyzed at « Hainaut Analyses » Laboratories in Ath** : https://ha.hainaut.be/