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Applications of biochar in viticulture

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In the past decade, what is now known as 'biochar' has been widely endorsed for a variety of industrial applications and has seen exponential interest in agronomic uses. However, its use remains limited in the viticulture sector, particularly in France. This paper provides a synthesis of recent publications on biochar applications in the sector.

Biochar: a little-known tool for grape and wine producers

Biochar is presented as a solution for reducing greenhouse gas emissions by 12 %, while increasing crop productivity[1]. The proliferation of publications on the subject–from 200 occurrences in 2010 to nearly 40,000 today (Clarivate Web of Sciences, September 2024)–demonstrates the significant interest in it, especially for its agronomic applications. Less than 100 studies to date concern the viticulture sector, and in France, more than 80 % of surveyed winemakers are "insufficiently informed" or entirely unaware of this practice[2].

Definition and characteristics of biochar

The word 'biochar' is a neologism derived from 'biological charcoal', which is produced *via* the pyrolysis (high-temperature, low-oxygen thermoconversion) of biomass, most often plant-based and rich in lignin, cellulose, and hemicellulose.

Due to its physicochemical characteristics (high stable carbon content, large surface area for exchange and adsorption capacity, cation exchange capacity, high surface charges, and microporous structure), biochar acts like a "sponge" in the soil, buffering water and mineral supply to plants.

In line with results from other sectors, the source of viticultural biomass (vine cuttings, pruning wood, and stems) appears to have less impact than pyrolysis temperature on the properties of the resulting biochar: the higher the temperature (above 500 °C), the greater its stable aromatic carbon content and microporosity, which increases its water retention capacity[3].

However, the heterogeneity of biomass sources, production conditions, as well as the variability in application conditions (soil types, plants, and climate) would ideally require detailed characterisation of each type of biochar, in order to adapt its use to specific conditions.

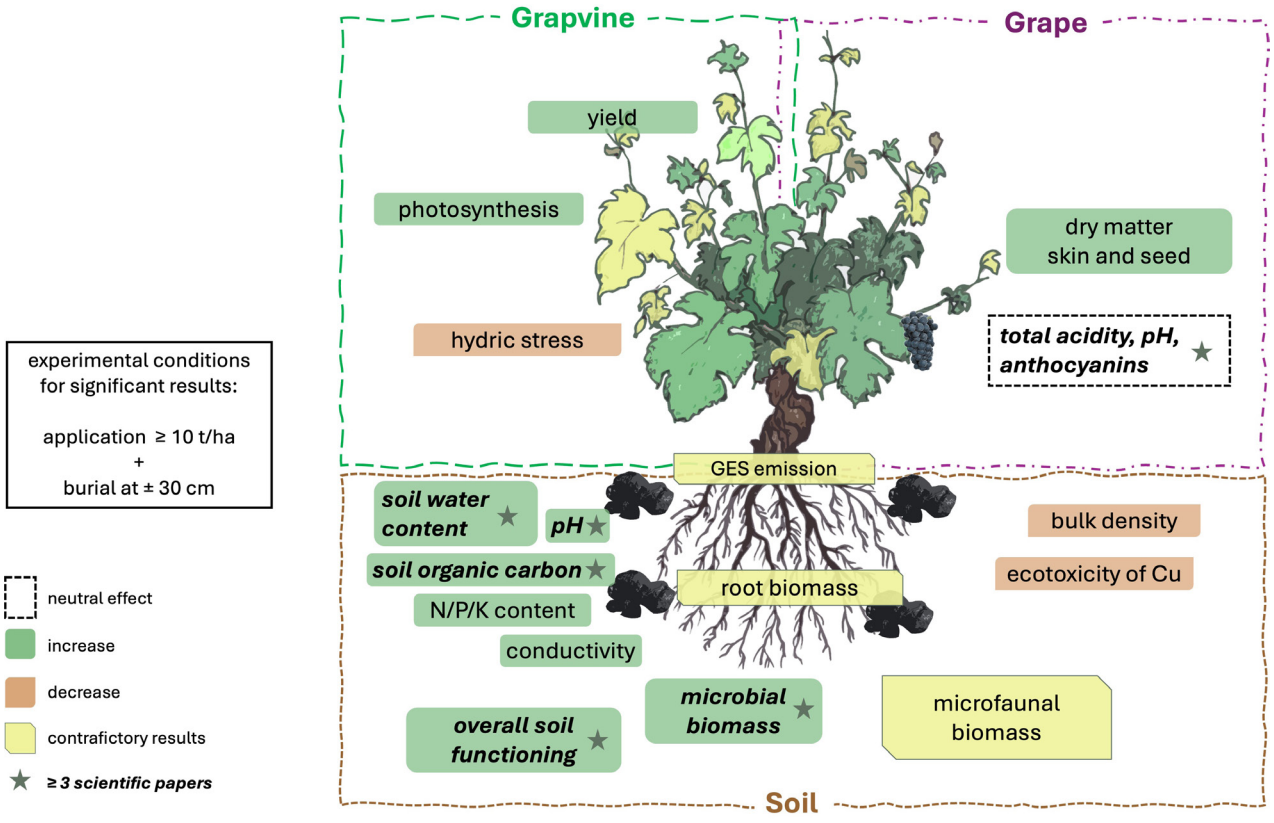

FIGURE 1. Summary of significant effects of biochar in viticulture, reported in 17 peer-reviewed scientific publications from international journals, between 2014 and 2024.

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Biochar as a soil amendment in viticulture

The few studies that have concluded that Biochar does not have significant or economically relevant effects as a soil amendment in viticulture generally involved low application doses and surface-level application, and were often conducted on alkaline soils.

When applied near the roots (typically buried at ± 30 cm depth though soil scratching), studies report the positive effects of biochar on numerous soil parameters (increased water retention, reduced density, higher pH and conductivity, increased C/N/P/K content *via* direct organic carbon input or by adsorption and reduced leaching, and stimulation of microbial activity, etc.), as well as plant parameters (reduced water stress, increased photosynthetic activity, and yield) without any notable impact on traditional grape parameters (pH, total acidity, alcohol potential, anthocyanins, and assimilable nitrogen); these results are summarised in Figure 1.

Short-term studies (a few vintages) sometimes show contradictory results, reflecting biochar's high stability and the complexity of its effects, particularly on the organic matter cycle in the soil[4].

Long-term studies on biochar's impact in viticulture are particularly relevant, though rare. A decade after a single biochar application, its effects on soil functionality in terms of water retention, chemical fertility, and biological activity still appear to be significantly positive, with improved overall fertility in biochar-amended plots without harming soil microbiota biodiversity or function. Additionally, a reduction in fine root biomass in surface horizons where biochar was applied seems to indicate vine plasticity in response to more accessible water resources, making biochar a tool of interest in vineyards subject to drought and without irrigation options[5].

Experimental biochar studies cover a wide range of climatic conditions and viticultural soils. The most significant results often occur on acidic soils, relatively low in organic matter, as found in many viticultural soils subject to leaching and erosion.

The organoleptic properties of grapes and/or wines from biochar-amended treatments have not been found to be affected, whether in sensory analyses or in chemical compound analyses.

Biochar as a value-added product for viticultural byproducts

Utilising vine prunings for biochar would have a positive carbon balance, allowing for a reduction of 18 g of CO_2 equivalent per bottle produced compared to burning[6].

While its use as an amendment has the best environmental impact, viticultural biochars also exhibit excellent characteristics as fuel for the energy sector[7]. The creation of "super-biochars", through physicochemical activation multiplying their CO_2 capture ability, also presents industrial prospects for biogas purification[8].

Other applications in viticulture

Biochar could stabilise soils heavily affected by erosion, reducing runoff and subsequent soil loss. Biochar's microporous structure also allows more specific practices to be applied, such as the optimisation of nursery growth substrates or inoculation using beneficial microorganisms to control soil-borne diseases like vine black-foot disease.

Conclusion

Biochar use remains relatively rare among winemakers, particularly in France. However, given its recognised agronomic properties and applications, there is no doubt the sector can adopt this new tool, enabling ecologically virtuous valorisation of vine by-products (uprooted vines, prunings, stems, etc.), whether for short-circuit amendments, the energy sector, or more specific applications within and outside the viticulture industry.

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The list of scientific articles consulted for this synthesis is available here: https://ives-technicalreviews.eu/article/view/9286/45029

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