

Technical Report on Edaphoclimatic Stress, Salinity Management and Bio-input Integration in Arid Viticulture Systems of Baja California

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1. Historical and geographical Context of Viticulture in Mexico

- Mexico was the first North American region to cultivate grapevines (*Vitis vinifera* L.), with the first vines planted around 1629.
- 17 Mexican states include wine production as part of their economic development, with Baja California (BC) leading in wine grape production, totaling 4,365 ha of vineyards and 170 wineries.
- The region exhibits a semi-arid Mediterranean climate with high temperatures (>30–40 °C) and low annual precipitation (<150–300 mm yr⁻¹).
- Viticulture is constrained by water scarcity, soil salinization, and climate stress, affecting long-term productivity and sustainability (Figure 1).
- These edaphoclimatic constraints demand adaptive management strategies focused on soil regeneration and climate resilience.

2. Methodology

This report defines edaphic and climatic limitations of viticulture in BC and explores the potential of bio-inputs and circular economy strategies for soil regeneration and climate resilience. The methodology included peer-reviewed (2015–2025) enhanced by observation notes and on-site interviews with winemakers and field technicians.

3. Terroir of Baja California and constraints for viticulture

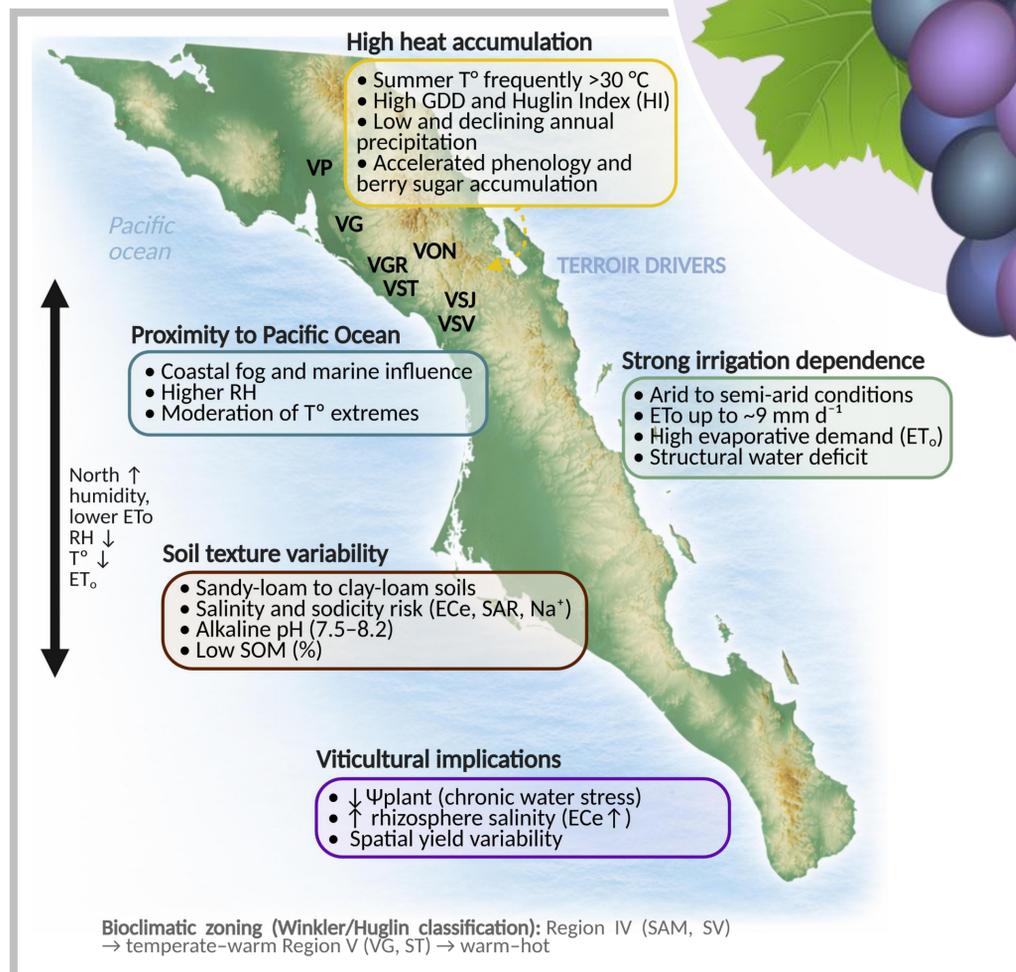
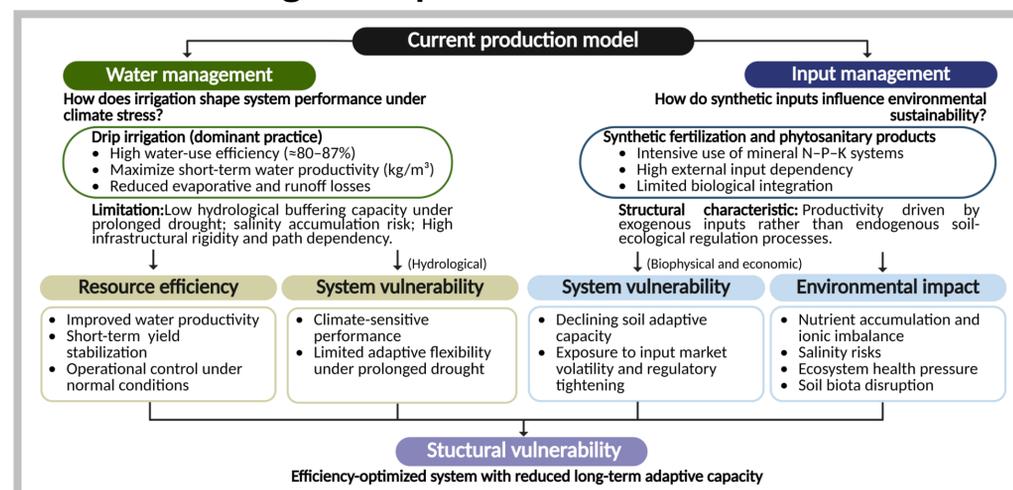


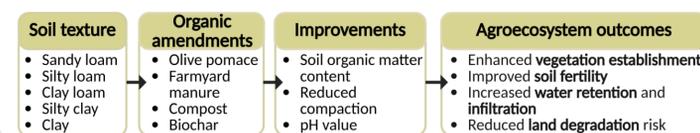
Figure 1. Edaphoclimatic drivers and barriers to viticulture in Baja California, Mexico. **Abbreviations:** VP: Valle de las palmas; VG: Valle de Guadalupe; VON: Valle de Ojos Negros; VGR: Valle de la Grulla; VST: Valle de Santo Tomás; VSJ: Valle de San Jacinto; VSV: Valle de San Vicente; GDD: growing degree days (Winkler index); HI: Huglin index; ETo: Reference evapotranspiration; ECe: Electrical conductivity of the saturated soil extract; SAR: Sodium adsorption ratio; Na⁺: sodium ion; SOM: soil organic matter; RH: relative humidity; Ψ_{plant}: Plant water potential. Created in <https://BioRender.com>

4. Current management practices and their effectiveness

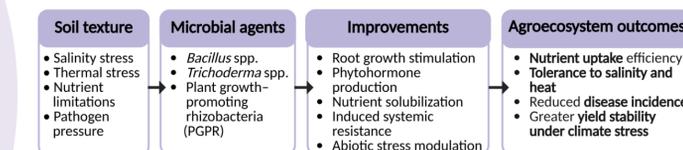


5. Biological inputs - tools for resilience

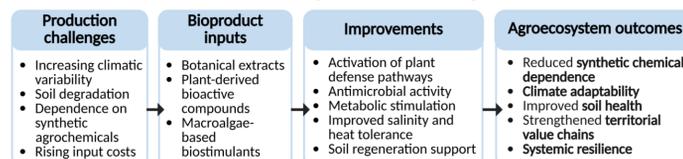
5.1. Incorporation of organic amendments



5.2. Microbial inoculants



5.3. Plant-based bioprotective products



7. The circular bioeconomy as a territorial model

Circular economy initiatives are advancing by reusing agricultural, winemaking, and mariculture residues in regenerative production cycles. Current actions include producing biochar from wood waste, generating vermicompost, and using its leachates as microbial inoculants, as well as incorporating compost as a source of organic matter. In parallel, soil biogeochemical cycles are being monitored, and bioproducts, such as biostimulants, are being adopted. Valorizing by-products, innovating bio-inputs, and coordinating among producers, academia, and industry strengthen the wine-growing sector's resilience and reduce its dependence on linear resource flows.

Conclusions and future perspectives

BC viticulture is threatened by several edaphoclimatic factors that are difficult to counteract in a semi-arid environment.

Applying circular economy principles to tailored circumstances promotes sustainable growth and increased resource efficiency.

Local innovation is thriving, as exemplified by Algas Pacific's pioneering biostimulant products from local macroalgae.

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