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Editorial: The role of agave as feedstock within a sustainable circular bioeconomy

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Editorial on the Research Topic
The role of agave as feedstock within a sustainable circular bioeconomy

Introduction

Agave within a sustainable circular bioeconomy goes beyond simply replacing fossil-based feedstocks with renewable biological resources. Instead, it requires sustainable supply chains, promising disruptive conversion technologies for sustainable transformation into biobased products, materials, and fuels (Tan and Lamers, 2021). A circular bioeconomy model aims to integrate the biological recovery of organic resources and nutrients from waste into a circular economy scheme (Davis et al., 2016; Díaz-Vázquez et al.). *Agave* is native to semiarid and arid regions of North and Central America and possesses several morphological, anatomical, and physiological drought resistance mechanisms, most notably crassulacean acid metabolism (CAM). In contrast to C_4 feedstocks, like sugarcane, switchgrass, and *Miscanthus*, which have a water-use efficiency (WUE) that limits them to areas with relatively high annual rainfall, *Agave* possesses remarkable heat tolerance and WUE (Nobel, 1998; Borland et al., 2009; Davis et al., 2014; 2017; Jones et al., 2020). Even in these extreme environments, and with few nitrogen (fertilizer) inputs, agave plants produce yields comparable to other second-generation bioenergy feedstocks (Lewis et al., 2015; Davis et al., 2017; Jones et al., 2020). Different *Agave* species have been cultivated historically throughout the world, and some varieties are currently being developed for expanded commercial production in Australia, Brazil, and Mexico, with increasing interest in the United States and several African countries.

Some of this growing interest is motivated by global climate changes that present challenges for agricultural production systems. Some *Agave* species are predicted to have increased biomass production in future climates on semi-arid, abandoned, marginal, or degraded agricultural lands (Davis et al., 2021). The economic importance of *Agave* for fiber and spirits production (mainly in Brazil and Mexico) is clear, with 2.62 million tons of *Agave tequilana* produced in 2022 for Tequila (CRT, 2023) and other traditional mezcals now also internationally recognized and traded with Appellation of Origin status (Davis and Ortiz-Cano, 2023). Interest in *Agave* research and applications continues to increase due to its predicted resilience to the impacts of climate change (Davis et al., 2021). The predicted impacts of climate change are 62% lower for *Agave* than corn and 30% lower than sugarcane, which are two other primary bioenergy feedstocks. The ability for *Agave* to survive in marginal semi-arid landscapes reduces the impact on other agricultural production systems. This will become increasingly important with agricultural production under pressure from a changing climate and higher demands for agricultural commodities from an increasing population (Crawford et al.).

An overview of the articles published on this Research Topic

This Research Topic has featured five articles on *Agave* within a circular bioeconomy. In the following, their main contributions are highlighted.

- Yeast community composition impacts on tequila industry waste treatment for pollution control and waste-to-product synthesis: This article assesses the treatment and revalorization potential of tequila vinasses (TV) using mono and mixed yeast cultures to produce single-cell protein (SCP) and to analyze yeast community composition using high-throughput sequencing during the mixed-culture fermentation of tequila vinasses. The evaluated yeasts (*Candida utilis* and *Kluyveromyces marxianus*) successfully employed TV as a growth medium with an estimated potential to produce 45,664 tons of protein feed yearly (Díaz-Vázquez et al.).
- Optimal planting density of *Agave* for maximizing aboveground biomass: A systematic literature review: This paper aims to assess the available research on *Agave* species, which reports planting densities and yield, and then recommend an optimum planting density for greatest productivity from available research using meta-analysis. Based on the findings of Nobel (1998), the hypothesized optimum density is 2,500–3,400 plants/hectare (ha) for *Agave*, which will equate to 21 Mg ha^{-1} y^{-1}. The meta-analysis in this global systematic literature review revealed an optimum planting density of 2,600 plants/ha with a dry aboveground biomass yield of approximately 28.8 Mg ha^{-1} y^{-1} (Crawford et al.).
- Molecular epidemiology of sisal bole rot disease suggests a potential phytosanitary crisis in Brazilian production areas: In this study, the authors develop a more reliable and user-friendly molecular marker for accurate *Aspergillus welwitschiae* identification through the identification of exclusive regions within its genomes. After the marker validation, it was employed in *Agave sisalana* conducting an epidemiological investigation where a pathogen was found with an incidence of 78%–88%. In this regard, the dispersion index indicates a regular spatial pattern for disease distribution, suggesting that the use of contaminated suckers to establish new fields may be the main disease-spreading mechanism (Raya et al.).
- Analysis of protein-protein interaction and weighted co-expression networks revealed key modules and genes in multiple organs of *Agave sisalana*: In this manuscript, the authors predict 2582 interactome components in *Agave sisalana* using public transcriptome sequences generated from leaf, stem, and root tissues. In addition, the identification of key modules and their association with three different organs from co-expression analysis which play the role of abscission can be part of further improvement studies to accelerate or repress flowering (Carvalho et al.).
- Rescuing the Brazilian *Agave* breeding program: morphophysiological and molecular characterization of new germplasm: This manuscript reports the evaluation of 21 *Agave* accessions as potential breeding materials being grown in the field where a novel marker based on the *Mayahuelin* gene was employed and 34 morphophysiological traits were analyzed to acquire insights into the prevailing accessions in Brazil for selecting more productive and climate-resilient cultivars for biorenewables production (Raya et al.).

Author contributions

JP-P: Writing–original draft. HM-A: Writing–review and editing. SD: Writing–review and editing. DT: Writing–review and editing.

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Conflict of interest

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