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EDITED AND REVIEWED BY
Maryke T. Labuschagne,
University of the Free State, South Africa

*CORRESPONDENCE
Miroslava Rakočević
✉ mimarako@unicamp.br
Fábio Luiz Partelli
✉ partelli@yahoo.com.br
Willian dos Santos Gomes
✉ gwill.bio@gmail.com

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Editorial: Sustainable coffee production

Miroslava Rakočević[1,2]*, Fábio Luiz Partelli[1]* and Willian dos Santos Gomes[1]*

[1]Department of Agricultural and Biological Sciences, Centro Universitário Norte do Espírito Santo (CEUNES), Universidade Federal do Espírito Santo (UFES), São Mateus, ES, Brazil, [2]Plant Physiology Laboratory (LMGV), State University of North Fluminense (UENF), Campos dos Goytacazes, RJ, Brazil

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Editorial on the Research Topic
Sustainable coffee production

Increasing demand for coffee creates pressure on farmers to increase production at the expense of the environment and workers. Some of the main adaptation strategies proposed for ensuring the resilience of the coffee farming sector under climate change are the application of new crop and soil management technologies, relocation of coffee farming areas, and changing the crops by using new cultivars, hybrids, or species (Davis et al., 2021). Small farmers usually do not have the option of relocation, but they can find solutions in cooperative coffee certification, helping farming practices that meet environmental, social, or economic sustainability standards, and access to the specialty coffee market, which reduces production costs, diversifies incomes, and addresses livelihood needs (Martinez et al., 2024). In this context, the Research Topic entitled "*Sustainable coffee production*" aimed to fill these gaps and provide some new insights.

Agricultural irrigation accounts for 70% of water use worldwide. Nguyen et al. investigated a sustainable alternative to help farmers use the available water for irrigation of *Coffea canephora* cultivations in Vietnam, where irrigation is predominantly performed from heavily depleted aquifers. A ThIRST smartphone app was developed, using three input variables, current soil moisture content, land slope, and seasonal precipitation forecast. This tool allows farmers to continuously achieve water-use efficiency and adapt to climate variability. The ThIRST app also provides advice on different aspects of coffee farming, such as fertilization, pest and disease management, intercropping, pruning, mulching, and registration of farm practices.

The development of technologies that permit sustainable fertilizer management, especially phosphorus (a finite and non-renewable resource) is crucial. Siman et al. explored the dynamics of phosphorus reservoirs related to coffee production and their implications for sustainability, especially in tropical soils. Adopting management strategies that incorporate alternative sources of phosphorus, such as organic residues and phosphorus-solubilizing microorganisms, can reduce dependence on fertilizers and improve production sustainability. The study suggests that integrated nutrient management, combined with soil conservation, is essential to maintain long-term productivity and mitigate the environmental impacts associated with excessive fertilizer use.

Vilchez-Mendoza et al. tracked the coffee berry borer in Costa Rica, the most important pest in coffee cultivation worldwide. Movements were followed from neighboring coffee plantations to adjacent land uses. This pest moves to adjacent land uses when the coffee resources in the infected plots are limited. Abandoned coffee areas are the source of the coffee berry borer for adjacent plantations, hosting pest populations for up to 2 years after abandonment. The authors' suggestion is that forests can be planned as natural barriers to the movement of the coffee berry borer, based on their vegetation complexity and size, which modify the direction and speed of the wind, preventing the transport of the pest. This implies planning sustainable landscape construction.

León-Burgos et al. analyzed the load of fruits, the most competitive functional sink organs in plants, to understand the biomass investments and functioning of the *C. arabica* plant. In plants with 100% fruit load, a decrease in the total number of leaves, leaf area-to-fruit ratio, and branch growth was observed. This occurred together with reduced dry mass allocation to leaves and branches, the latter having a negative correlation with fruit dry mass accumulation. High fruit loads reduced the magnitude and rate of plagiotropic growth of vegetative organs. Interestingly, the increased fruit load did not alter beverage quality, but it did alter vegetative growth, dry mass partitioning, and the physical quality of the beans.

Osorio et al. evaluated the chemical and sensory characteristics of coffee at three stages of maturity and their modifications under four storage conditions. The fruit maturity stage affected the chemical composition, which was dependent on the interaction between temperature and storage time. Additionally, increasing the storage time from 24 to 48 h resulted in an increase in sensory defects, indicating that a longer storage time led to a greater probability of the appearance of sensory defects. On the other hand, the increase in storage time from 24 to 48 h was associated with an increase in the fruit and red fruit (positive) descriptor groups.

The sensory quality potential of Robusta genotypes from the Coffee Collection in Yangambi, DR Congo, was analyzed (Bollen et al.). Among 70 genotypes, the nutty/cocoa sensory descriptor class was the most frequently reported, characterized by a high frequency of fruity, sweet, and sour/fermented descriptors, with a low frequency of green/vegetative, and roasted descriptors. The total cupping score ranged from 75.75 to 84.75, with stability in sensory profiles over 2 harvest years. Interestingly, some genotypes with unique sensory profiles were discovered within the cultivars and the wild–cultivar hybrids. Only a fraction of the diversity of available cultivated and wild *C. canephora* genetic resources in DR Congo has already revealed the potential to improve the sensory quality of cultivated Robusta coffee.

Ngure and Watanabe emphasized the need for a paradigm shift in breeding strategies toward the development of resilient coffee varieties able to withstand extreme climatic conditions and other stresses. The study advocated for a collaborative breeding approach, encouraging the sharing of genetic resources and knowledge to improve breeding efficiency. Additionally, it highlighted the importance of genomics-assisted breeding and cross-border multi-environmental trials to accelerate the development of superior coffee varieties suited to diverse local conditions. Overall, the review underscored the need for innovative and cooperative efforts to ensure the future sustainability of the global coffee supply.

Finally, this Research Topic on "*Sustainable coffee production*" highlights the essential role of an intensive search for sustainable solutions in the long chain of coffee cultivation, management, and use. The seven presented papers come from the Tropic of Cancer to the Tropic of Capricorn, essentially from three continents that produce whole "golden" dark beans, but they are also the result of the cooperation with some institutions in the Northern hemisphere. The sustainable actions presented are related to genetic selection, environmental management, landscape management, and the search for coffee bean quality and yield respecting and developing the sustainable concepts of circular economy. They bring some new insights with the potential to indicate how to mitigate the impact of predicted environmental changes.

Author contributions

MR: Writing – original draft, Writing – review & editing. FP: Writing – original draft, Writing – review & editing. WS: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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