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Editorial: Coffee: From the field to the cup

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Editorial on the Research Topic
Coffee: From the Field to the Cup

Along with the pages of this volume, the reader will meet many more challenges than solutions, which we hope will motivate new studies and development of innovative approaches to improve coffee cultivation under the looming challenges of climate change. Since the discovery of use of coffee as a beverage and its expansion of cultivation to regions outside of Ethiopia and Yemen, coffee cultivation has not been without challenges.

Catarino et al. enlightens how atmospheric elevated CO_2 concentrations and progressive drought affect the coffee-plant physiology and metabolism. Young coffee plants were grown under actual and enriched CO_2 (800 ppm) concentrations and either exposed or not exposed to water deficit. Photosynthesis and water use efficiency was improved even under drought. There were changes in the biochemical composition of leaves, markedly a decrease in phenolic compounds under elevated CO_2, regardless of the water regime. Chlorogenic acid and caffeine increased under the combination of water deficit and elevated CO_2.

Nitrogen (N) is the most abundant nutrient taken from the soil by plants, and nitrate (NO_3) is the main nitrogen form absorbed by plants, which transport through the root cell membranes is mediated by low- and high-affinity membrane transporters. Bohórquez et al. studied the variations in N uptake during four coffee fruit developmental stages. Rapid fruit expansion was the developmental period when the kinetic parameter V_{Max} showed a positive relationship with bean production. They also observed that at maturation, because of a decrease in carbohydrate demand, fine roots were more abundant than at the grain filling stage. Because these fine roots mostly absorb nutrients, water shortage might compromise N uptake because of root mortality.

The prospection and maintenance of coffee germplasm is crucial to breeding coffee programs aiming to produce plants adapted to the global warming scenario. In this regard, two articles were published on this Research Topic. Krishnan et al.

used simple sequence repeat (SSR) markers to assess the genetic diversity of wild and cultivated populations of Arabica coffee from the Boma Plateau in South Sudan, which has been suggested as a center of origin of *Coffea arabica* species, in addition to Ethiopia. Comparing these populations with accessions from Ethiopia, Yemen, and global cultivars, they confirmed their hypothesis and showed that the wild population analyzed was genetically distinct from Ethiopian Arabica. Because Arabica coffee is an autogamous species, thus with low genetic variability, South Sudan coffee population can be a rich material to be explored in breeding programs.

In another paper, Dullo et al. evaluated the genetic accessions found in the coffee germplasm of CATIE International Coffee Collection (CICC) in Turrialba, Costa Rica, which has genotypes from all over the world, including from missions organized by several organizations to collected wild genetic material in Ethiopia. The methodological approach they created for an in-depth assessment of the collection can be used for other collections and help breeding programs.

To face the challenge of climate change and ensure resilience to coffee plantations, Davis et al. consider the relocation of the coffee plantations to more suitable areas and replacing the available cultivars with new hybrids and/or species as appropriate strategies. Aiming to improve our knowledge of two coffee species, *C. racemosa* and *C. zanguebariae*, and based on the lacunas of several previous works, they studied the phylogenetic and spatio-phylogenetic relationship to confirm or refute their existence as separate species. They also studied their climate requirements and agro-climatic suitability, obtained preliminary sensory (flavor) information, and provided primary agronomic data. The authors concluded that both species have traits that could be explored in breeding programs. Among the traits, the authors cited heat tolerance, low precipitation requirement, high precipitation seasonality (dry season tolerance) and rapid fruit development, which are characteristics considering global warming and changes in the water regime in traditional areas of coffee plantations.

Because of the narrow genetic basis and low diversity of *C. arabica*, Medeiros et al. integrated molecular characterization, genetic diversity analyses, and circulating diallel studies aiming to develop a strategy to select new cultivars. They used molecular markers to assess the genetic diversity of 76 candidate parents and verify the crossing of potential F1 hybrids. They selected eight elite parents for circulating diallel analysis. The parents and 12 hybrids were evaluated based on 10 morpho-agronomic traits. Medeiros et al. concluded that with this approach it is possible to identify elite plants which can be used in breeding programs to develop new cultivars in response to global climate changes.

Coffee quality is a result of the genetic background, environment and fruit processing, and the interactions among these three factors. Malta et al. studied the importance of the genetic background in the beverage quality of 31 elite cultivars of *C. arabica*. The fruits were wet-processed, and the sensory profile of the beans was characterized and compared using multivariate statistical tools. The authors could discriminate the genealogical groups using chemometric analysis, Principal Component Analysis (PCA) and Partial Least Squares Discriminant Analysis (PLS-DA). Using this approach, they selected three elite cultivars with scores equal to or above 90 points. The authors discuss the influence of the genetic background of each group in the results obtained.

C. arabica originally grew in the understory forest of Ethiopia, but nowadays, cultivars of this species are primarily grown in full sunlight. In recent years several crops have been cultivated under agroforestry systems. The coffee agroforestry system has been adopted in many tropical countries as a sustainable practice bringing better and more stable income, mainly for smallholder farmers. Bertrand et al. proposed breeding coffee to select plants productive under shade conditions. They replicated an experiment in the shade and sun and, following several characteristics, reached conclusions regarding the selection of candidate varieties suitable for the coffee agroforestry system, which could target different markets. For example, by choosing the F1 hybrids, they believe it is possible to increase productivity under shade and full sun and at the same time select for good sensory qualities.

Shading has also been adopted in coffee plantations in the Central Highlands, the main coffee-growing area of Vietnam. Le et al. analyzed the transition of sun cultivation coffee to shade in a small ethnic minority village in Lâm Đ*ông province. They observed improvement in the biodiversity and that the soil of the shade-grown coffee farms was enriched with organic matter. Because of a decrease in the inputs, they also found that the net return in the shade system was almost four times higher than in the full-sun system.

Siles et al. also studied the process of small farmers' adoption of coffee agroforest systems in Nicaragua. The authors found several gaps still to be filled regarding food and income benefits. Decreasing coffee margins, labor scarcity, pests, and climate variability allows small coffee farmers changes regarding coffee varieties and associated trees. The authors also had important insights to improve data collection, enabling a more in-depth analysis to design new strategies for agroforestry transformation in Nicaragua.

Venzon reviewed the adoption of an agroforestry system, cover crops, and non-crop plant management in coffee plantations as sustainable tools to control coffee pests. Fruit and wood trees used to generate biodiversity could provide an additional income for small coffee farmers. Additionally, the production of coffee under these systems may support small farmers entering the specialty coffee market.

Koutouleas et al. comprehensively reviewed the literature on coffee shading as a strategy to grow coffee and mitigate and adapt the crop to future climate changes. The review gives elements to the reader plan and anticipate strategies for future challenging climate conditions, as well as provides elements for future research, from breeding programs to practical management of the coffee-agroforestry system.

Ripper et al. were the first to compare the composition of the exotics coffees Jacu and Kopi Luwak and report a comprehensive chemical analysis. The data showed some consistency regarding changes in the chemical composition of both exotic coffee, mainly caffeine and chlorogenic acid.

Author contributions

HPM and PM wrote the first draft of the editorial. SK, SALA, and MBAG made corrections to the text. All authors contributed to the article and approved the submitted version.

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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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