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Editorial: Sustainable cropping systems for small grain crops for smallholder farmers

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Editorial on the Research Topic
Sustainable cropping systems for small grain crops for smallholder farmers

Climate change has negatively impacted the smallholder farmers in Africa, leading to variability in rainfall and weather conditions that have reduced crop yields (e.g maize to below 1.5 t ha^{-1}). These farmers lack sufficient adaptive capacity and cannot adopt mitigation interventions. Small grains such as sorghum, millet, and finger millet are resilient to climate but they are not widely adopted due to the high labor demands of their production, restricted market access, weak policy support, and consumer preferences. Additionally, these crops are often grown on poor soils with low input, which leads to reduced yields. Solutions to low yields include conservation agriculture, intercropping with legumes, agroforestry, and better pest, water, and nutrient management. Increasing productivity requires improved agronomic management, high-yielding varieties, post-harvest handling, and linkage to markets. Overcoming these issues can enhance food security and resilience among smallholder farmers.

A cost–benefit analysis of the production systems

Coulibaly et al. evaluated the profitability of adopting improved sorghum varieties (ICRSVs) compared to local varieties. Drawing on a farm partial budgeting method, sensitivity analysis, and stochastic dominance analysis across three years of yield data (2017, 2018, 2020), their study was undertaken in the Sikasso region. The authors showed that ICRSVs such as "Soubatimi" and "Tiandougou-coura" were profitable, achieving net incomes of 79,661 and 45,073 CFA francs, respectively, while local varieties caused losses. This study highlights that the dissemination of ICRSVs can improve the livelihoods of smallholder farmers and proposes policy interventions to streamline adoption rates, such as outreach programs and fodder market development. However, the research places

restrictions, for example, on excluding fodder yield statistics, which would further enhance profitability.

The impact of access to climate services on cropping decisions

Nocezo et al. examined the impact of climate services on on-farm-level decision-making and food security. A cross-sectional study and propensity score matching (PSM) were employed, and data were collected using questionnaires from 217 farmers in the Elundini municipality, Eastern Cape province, South Africa. The results indicate that, while 69% of the farmers utilize weather forecasts, only 24% utilize seasonal forecasts. Access to climate services positively and significantly impacts daily farm activity decision-making, planting dates, crop varieties, and land preparation. Nocezo et al. noted that approximately 35% of the respondents reported experiencing food insecurity, but access to climate services improved household dietary diversity scores. The study recommends scaling up access to climate information and its integration into agricultural extension services to assist in building resilience and food security.

A GIS-based analysis of agro-land suitability

Kumar et al. assessed the suitability of agricultural land for wheat cultivation in Gujarat, India, particularly in the Bhal region. Multi-Criteria Decision Analysis (MCDA) and Geographic Information Systems (GIS) were used to evaluate 17 parameters such as soil texture, nutrient content, and slope. The results classified 24.80% of the land as "highly suitable," 31.37% as "moderately suitable," 12.40% as "least suitable," and 31.43% as "not suitable" for wheat cultivation. Kumar et al. observed that nitrogen and micronutrients (Mn, Fe, Zn) were deficient, hence the need for fertilizer application. The Ahmedabad and Kheda districts were found to be more suitable and the Bhavnagar district was found to be the least suitable. There is an evidence-based justification for ensuring maximum land use, enhancing wheat production, and ensuring food security in the region.

Agronomic management practices for quinoa cultivation

This systematic review investigated quinoa cultivation practices in 148 global field experiments conducted from 2000 to 2022. The crop is tolerant to drought and salt and has been grown beyond the Andes due to its nutritional quality and resilience. Taaime et al. observed that quinoa yields are extremely heterogeneous (108-9,667 kg ha^{-1}) and are genotype-, sowing date-, and agronomic management- dependent. Optimal planting periods are region-specific to avoid climatic stresses such as frost or heat. Fertilization is necessary, with 2-4.6 kg of nitrogen needed per grain quintal. Quinoa is moderately tolerant of low irrigation (300–400 mm), but yields are maximized with 866 mm of water available. Weed control relies heavily on manual labor, and downy mildew and birds are the main pests. Post-harvest removal of saponin can be done using washing or mechanical pearling. This review provides the first global, extensive guidelines for quinoa production, highlighting the importance of genotype choice, adjusted sowing dates, and eco-friendly practices to maximize yield and environmental resilience.

Socioeconomic and geopolitical factors affecting the crop selection of smallholder farmers

Zakirova et al. conducted a qualitative study to investigate smallholder farmers' response to adjusting their crop selection during crisis periods (2019-2022), including the COVID-19 pandemic and the Russia-Ukraine conflict. Historically, the region had been subject to state-ordered cotton production, but farmers have faced deficits in inputs (e.g., fertilizers) and rising expenses and, therefore, have shifted to food crops such as wheat, maize, and vegetables for household use and income. Richer farmers adopted innovations such as greenhouses and hybrid seeds, whereas poorer ones relied on traditional practices or sharecropping. The diversification of livestock and crops became a resilience strategy, but limited land and resources constrained long-term sustainability. This points to the tension between state cotton policy and farmers' survival needs, with their adaptive strategies providing a foundation for socioeconomic and geopolitical uncertainty. Support from NGOs in the form of training and government action to modernize agriculture in a manner that ensures food security are necessary.

Enhancing rainfed small grain crop productivity

Mosalman et al. examined the impact of intercropping chickpea and safflower with and without the application of biostimulants (salicylic acid, SA; selenium, Se) in conditions where water is limited. The trial was carried out using three levels of biostimulants (control, SA, Se) and five planting patterns (monocrop and three proportions of intercropping). The authors found that safflower treated solely with Se accumulated the highest biomass and seed yield, whereas sole chickpea growth was most ideal in its monocrop. The 3S:5C intercropping proportion with Se increased safflower oil to an optimum (32.08%), whereas the 2S:4C proportion with Se increased unsaturated fatty acids. Intercropping promoted stress-related traits such as chlorophyll, proline, and antioxidant enzyme activity more than monocropping did. The

1S:2C proportion boasted the highest land equivalent ratio (1.81), which was 81% more productive than monocropping. SA and Se enhanced drought resistance and oil quality. In conclusion, intercropping safflower-chickpea with a biostimulant, particularly at ratios of 2S:4C and 3S:5C, was found to increase yield, resource use efficiency, and stress tolerance in rain-fed systems, offering a sustainable solution for water-scarce ecosystems.

In conclusion, this Research Topic focused on the potential of climate-resilient small grains (sorghum, millet) and sustainable practices such as conservation agriculture, intercropping, and agroforestry to enhance productivity. Farming interventions such as the use of improved sorghum lines, climate data to aid in decision-making, and land suitability analysis using GIS can boost farm productivity. Together, these strategies underscore the need for policy intervention, market access, and specifically tailored agronomic management to increase global food security and make farmers resilient to climate change.

Author contributions

CP: Writing – original draft, Validation, Writing – review & editing, Conceptualization. AN: Validation, Conceptualization, Methodology, Writing – review & editing. HM: Writing – review & editing, Conceptualization, Validation. ED: Validation, Writing – review & editing.

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Conflict of interest

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