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Achieving sustainable cultivation of sorghum

Volume 2: Sorghum utilization around the world

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Introduction

Sorghum is one of the world's major cereals, cultivated in the semi-arid tropics for a growing range of uses. Like other crops it faces the need to meet rising demand whilst reducing its environmental impact and adapting to the challenges of climate change. These challenges are addressed in the two volumes of *Achieving sustainable cultivation of sorghum*:

- Volume 1 Genetics, breeding and production techniques
- Volume 2 Sorghum utilization around the world

The chapters in this volume (Volume 2) discuss the varied uses of sorghum as a food grain, as well as a forage and energy crop. The volume also includes detailed case studies of key challenges facing sorghum cultivation in regions such as Asia, Africa and South America.

Part 1 Sorghum utilization

Chapter 1 addresses the structure and chemistry of sorghum grain. Sorghum is grown around the world under diverse environmental conditions. Combined with the high degree of genetic diversity present in sorghum, this can result in substantial variability in grain composition and grain quality. While similar to other cereal grains such as maize and the millets in some aspects, sorghum has many unique compositional traits which impact grain quality and utilization. The chapter reviews the composition of sorghum grain, including its physical structure, composition of bio-macromolecules and micronutrients such as starch, proteins, lipids, phenolic compounds and vitamins and minerals. The chapter also includes a summary of research showing how various factors can impact sorghum grain composition.

Following from the first chapter's focus on the chemistry and physiology of sorghum, Chapter 2 reviews the domestication, spread and uses of sorghum as a crop. Although only a minimal component of human food in developed countries, sorghum remains the fifth most important cereal crop in terms of production and acreage. This is due to its robustness as a cereal crop, biotic and abiotic tolerances, and diversity of both varieties and uses. The chapter describes the diversity of sorghum and related species, sorghum's anthropocentric origins, spread and domestication as well as reviewing its utility as both a source of nutrition for humans and domestic animals. The chapter also examines the population genetics of global sorghum and the crop's relationship to its wild relatives. The chapter covers early evidence of sorghum use and introduces the sorghum conversion (SC) program, as well as current techniques such as introgression of distant wild crop relatives and whole genome sequencing.

Returning to the theme of the structure of sorghum, Chapter 3 focuses on sorghum crop physiology and development. A thorough understanding of how grain sorghum develops is essential in determining how best to manage this crop. Grain sorghum has three predictable phases of growth: vegetative (planting to panicle initiation); reproductive (panicle initiation to flowering); and grain filling (after flowering to maturity). The chapter describes each of the phases in detail, observing how each stage is affected by factors such as genotype, temperature and photoperiod. Climatic conditions for optimal growth are discussed, as

well as the effects and physiological basis of drought, high temperature and elevated carbon dioxide tolerance. Due to climate change, sorghum-producing areas are facing increased exposure to water deficits and extreme temperatures, making understanding of plant response to environmental stresses even more important. The chapter concludes that the use of high-yielding varieties and proper management practices will be essential to the future of this crop.

Chapter 4 begins to analyse the uses of sorghum, considering sorghum's role as a food grain. Grain sorghum is the fifth most important cereal crop in the world, exceeded only by rice, wheat, corn and barley, and it is a dietary staple for more than half a billion people in more than 30 countries. Sorghum is a principal food in areas of Africa and Asia as well as being used as a raw material for alcoholic drinks and beverages. The chapter describes the protein and starch makeup of sorghum and the effects of cooking and processing sorghum on its digestibility and nutrient availability. The chapter assesses the protein quality of sorghum for human use, describes the sensory and functional characteristics of food products containing sorghum and outlines the health benefits of sorghum.

Continuing the theme of the uses of sorghum, Chapter 5 addresses the role of sorghum as a forage and energy crop. Sorghum is an important source of grain and fodder, forage, and biomass throughout the world. In the United States, grain sorghum is the prominent crop; however, non-grain sorghum plays an important role as a feedstock globally. The chapter reviews the different types of sorghum and their uses. The chapter begins by considering the types of sorghum used for forage and biomass, and then offer a detailed discussion of the use of forage sorghum as feed for ruminant animals. The chapter reviews the advantages of using sorghum as a dedicated energy crop, and finally considers the composition and uses of sweet sorghum cultivars.

Part 2 Sorghum production and improvement across the world

The second part of the book discusses ways of improving cultivation in regions such as South America, Europe, Asia and Africa. Chapter 6 examines the introduction of new technologies and market strategies for sorghum producers in developing countries, using the experience of the Sahel as a case study. Sorghum produced principally for home consumption is typically characterized by low yields, input use and market prices. These are interrelated but must be addressed using different strategies. The chapter reports on the field research of a program combining both agronomic and economic components. The program initially included four Sahelian countries and then focused on Mali as it moved from the pilot stage to implementation. The chapter focuses particularly on the introduction of new sorghum technologies and the improvement of marketing strategies, as well as the ability of the system to respond to emerging problems. The chapter examines sorghum performance and potential in Mali and Burkina Faso before considering strategies for breaking farmers out of subsistence. It outlines the success of the pilot project and methods for scaling up improvements, before considering second generation problems and the importance of institutional innovation in the form of farmers' associations as marketing cooperatives. Finally, the chapter considers the growth of a secondary market for sorghum.

Building on the themes of Chapter 6 but moving from Africa to South America, Chapter 7 examines the improvement of sorghum cultivation in South American countries. Sorghum production in Brazil has expanded significantly in recent years, with a current planted area of close to one and a half million hectares. Sorghum provides an excellent source of grain to feed cattle, poultry and swine, as well as forage for cattle, especially in situations of drought and conditions of low soil fertility. It can also be used in bioenergy production. The chapter reviews the history of sorghum production in Brazil, and then considers the improvements necessary to ensure that sorghum production can continue to meet demand, including improving sorghum tolerance for aluminium and lack of phosphorus. The chapter emphasizes the need to develop adapted sorghum cultivars which will grow well in tropical soils and produce crops suited to their particular uses. It addresses genetic and molecular approaches to studying biomass production and sorghum quality and examines the challenge of improving disease resistance, as well as outlining the pests of sorghum in the region.

Moving from South America to Asia, Chapter 8 considers the improvement of sorghum production and utilization in Asian countries. Sorghum was once a major crop in dry regions. However, its production area has decreased drastically, especially in Asia. In order to revitalise sorghum production, sorghum research must be reoriented to resolve current production constraints and improve productivity. The chapter reviews potential measures to improve sorghum cultivation in Asia, including genetic improvement, improved processing technologies, marketing strategies and policy measures.

The volume's final chapter, Chapter 9, returns to Africa to consider sorghum cultivation and improvement in West and Central Africa (WCA). The diversity of sorghum cultivated in Africa attests to the African origin of this crop. Farmers in West and Central Africa (WCA) have developed strategies of using varietal diversity to minimize risk and maximize productivity in the context of complex and diverse adaptive challenges. The chapter describes the major sorghum production systems, options for intensification and sustainable production, genetic diversity and opportunities to breed for enhancing sorghum crop value, as well as opportunities for progress in strengthening seed systems.

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