Preface

Legume species belong to the Fabaceae family and are characterized by their fruit, usually called pods. Several species of this family were domesticated by humans, such as soybean, beans, faba bean, pea, chickpea, lentil, peanut, lupine, pigeon pea, mung bean, peanut, or cowpea and many of them are of great relevance as human food and animal feed. Food legumes are typically consumed as dry seeds, which have high protein content, and in some cases as immature seeds or pods.

Members of the legume family, the Fabaceae or Leguminosae, fill critical niches in most terrestrial biomes. This is one of the few plant families whose species are capable of "fixing" nitrogen from the air, through association with specialized soil bacteria, for use as a natural fertilizer, thus reducing fertilizer requirements. The family has traditionally been divided into three subfamilies: Caesalpinioideae, Mimosoideae and Papilionoideae, this latter subfamily contains most of the major food and feed legumes.

Several grain legume crops are crucial elements of global agriculture and nutrition, both as food and feed since they are major sources of plant protein. Legumes contribute to the sustainable improvement of the environment when grown in agricultural rotations due to their ability of biological nitrogen fixation and their effects on the soil, and yield of the next crop, and the services given to other components of agroecosystems such as pollinators. Legumes play a key role in the diversification and sustainable intensification of agriculture, particularly in light of new and urgent challenges such as climate change. The overall objective is to increase the sustainability of the food and feed chain at all its steps, meet the requirements of citizens for safe, healthy and affordable food via the nutritional prevention of diet-related diseases and assure food quality and authenticity. Reducing energy and water consumption and optimizing process control contribute to making food processing and distribution more sustainable and the food sector more competitive.

The demand for plant proteins for human nutrition has increased over the past few decades in many countries due to: (i) demographic growth and urbanization, (ii) the limited land areas which can be used for production of food crops while farming systems are changing towards specialized cereal and oilseed production, (iii) a decrease in animal protein production due to shortage of irrigation and/

or rainfall especially, and (iv) deliberate reduction in red meat consumption for health reasons. Because of the high protein content of their seeds, grain legumes are attractive candidates to overcome the deficiency in plant protein production. However, in comparison to cereals, limited improvement in farming practices has been achieved over the past few decades to enhance the production of important grain legumes. A number of limiting factors affect legume yield, with water deficiency in quantity or quality being among the key ones, to obtain more stable and more reliable production. Even though these constraints have become structural in many agrosystems, very limited research and development efforts have been devoted to strategies to improve grain legume production under stress conditions to contribute to the development of sustainable agriculture worldwide.

Further, the decrease in legume cropping is linked to a heavier use of chemical fertilizers, pesticides and herbicides than in the past and an overall simplification of agricultural systems. This has reduced the level of above-and below-ground biodiversity in terms of macro- and microorganisms living in the agroecosystem and has caused an increased pollution of the environment, impairing the beneficial effects biodiversity has on crop productivity and the maintenance of agroecosystem services for future generations. In addition, the decrease in legume cropping in some agricultural areas urgently needs to be reversed as nitrogen fertilizers costs are increasing with rising energy costs, leading to high production costs for farmers, and substantial greenhouse gas emissions linked to the use of nitrogen fertilizers.

Also social and scientific issues should be considered. Interest in legumes has been decreasing among many farmers, breeders, processing sector entrepreneurs and scientists. Most worrying is the fact that knowledge on grain legumes with regard to growing legumes in rotations, appropriate harvesting, storage and preparation of the seed for further reproduction or processing have progressively been lost. In addition, the use of legumes in human diet is decreasing in many developed countries and knowledge on how to use legumes in food preparations is being lost, despite continued calls by the medical professions to include a wider range of plant proteins in the diet. To reverse these current trends, actions must be taken, to promote wider use of legumes in crop production that will enable significant benefits in economic, environmental and climate change spheres.

Approaches aimed at the improvement and exploitation of legume nutritional and technological qualities are needed and can be expected to drive consumers and farmers towards new, diverse, healthier and more sustainable choices. To contribute to the development of sustainable agriculture, special attention has to be paid to the factors limiting legume yield to obtain more consistent production and to fill the knowledge and development gap on strategies to improve grain legume production under stress conditions.

The decrease in manufacture of inorganic N fertilizers will result in reducing the emission of greenhouse gas. Nitrous oxide (N_2O) is produced naturally in the soil during the microbial processes of nitrification and denitrification; considered over a 100-year period, N_2O is a greenhouse gas with tremendous global warming potential (GWP) when compared to carbon dioxide (CO_2) since it has 310 times the ability per molecule of that gas to trap heat in the atmosphere. The decline of

soil fertility with loss of organic matter, the excessive use of chemical fertilizers, the inappropriate use of the scarce water resources and the increase in soil acidity and salinity, particularly in dry regions, all pose real threats to economic, social and environmental sustainability. Agricultural systems involving legumes represent a cheaper and more sustainable alternative to conventional practices by symbiotically capturing atmospheric N_2, thus reducing the use of industrially produced nitrogen in the production of field crops. Improved N management is needed not only to optimize economic returns to farmers but also to minimize environmental concerns associated with N use, namely leaching problems and water pollution.

Intercropping or crop rotation including legumes is a promising strategy for more sustainable crop production in many agricultural systems through the N transfer and N release from legume residue. In crop rotation, legume crops can be used in between of cereals or other cash crops (e.g., vegetables). The final contribution of fixed N_2 to the soil depends upon the legume species N balance, environmental conditions and agricultural practices.

Globally, grain legumes are the most relevant source of plant protein, especially in many countries in Asia, Africa, and Latin America, but there are some constraints in their production, such as poor adaptation, pests and diseases, and unstable yield. Current research trends in legumes are focused on new methodologies involving genetic and -omic studies, as well as new approaches to the genetic improvement of these species, including the relationships with their symbiotic rhizobia.

The book on grain legumes includes two parts. The first one consists of eight crop-specific chapters devoted to the most produced and consumed worldwide grain legume crops covering the whole range of topics related to breeding: origin and evolution, genetic resources, breeding achievements, specific goals and techniques, including the potential and actual integration of new technologies. The second part includes five cross chapters covering topics that relate to the different crops of the general chapters. All the chapters have been written by outstanding breeders and scientists with wide experience in their crops and topics. This handbook contains all the basic and updated information on the state of the art of breeding grain legumes. The vast amount of knowledge collected in this volume should not only serve breeders but also researchers, students and academicians. It may be regarded as a scientific knowledge platform that provides practical plant breeders with new scientific information, but also to make molecular biologists more familiar with the peculiarities of breeding of the main grain legume species.

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