Chapter

Introductory Chapter: Characterization and Improvement of Legume Crops

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1. Introduction

Legumes are agriculturally grown flowering plants that are found in most of the archaeological record of plants [1]. Various ecosystems, including rain forests, arctic/alpine regions, and deserts have been colonized by legumes [1, 2]. The most two popular flowering plants are Asteraceae and Orchidaceae [1]. The third in terms of popularity is Leguminosae or Fabaceae with 670–750 genera and 18,000–19,000 species, respectively [1]. Legumes are utilized efficiently as (a) food crops for humans and animals; (b) pulps for paper, wood, and timber manufacturing; (c) sources for fuel and oil production; (d) ornamental plants used as living barriers and firebreaks, among others [3]; and (e) cover crops such as cereals and other staple foods [1]. Additionally, they can be utilized for other purposes including production of massive amounts of organic nitrogen. This is because legumes can be intercropped with rhizobia resulting in high yield productivity, soil organic matter improvement, modification of soil osmosis and texture, nutrient reuse, decrease of soil pH and soil pressure, microorganism differentiation, and alleviation of disease problems [1, 4]. Furthermore, legumes can produce amounts of organic nitrogen at a slow rate when rotated with cereals. Such nitrogen produced can be utilized in prospective cropping technologies for improving the production of these crops, recognizing their potential role in promoting better human nutrition and soil health [1, 5].

2. Main legumes

Forage legumes such as alfalfa (*Medicago sativa*), clover (*Trifolium* spp.), bird's-foot trefoil (*Lotus corniculatus*), and vetch (*Vicia* spp.) are utilized as main sources for dairy and meat which are used for protein, fiber, and energy production [1]. Global production of alfalfa was approximately 436 tons in 2006 suggesting that it is the most essential forage crop. The highest amount of alfalfa was produced in the United States, being produced around 15 million tons in 2010 [1, 6]. Grain legumes or pulses are crops harvested massively for the dry seeds. They are found containing high amounts of protein in their seeds. Therefore, they represent a major food source for population consumption. They are considered as the main protein suppliers especially for people from developing countries [1]. Additionally, their high amino acid content is of nutritional value during utilization of cereals and tubers as food sources [1, 7]. The soybean (*Glycine max*), a native plant of Eastern Asia, is an annual summer legume of great agricultural possibilities due to its fundamental role in the nutrition of many people and livestocks besides its industrial possibilities [1, 8].

3. Enhancing legume productivity

Legumes are highly diversified, so they are utilized for several economic and cultural purposes including their role as vegetables to tolerate various ecological conditions, their source for producing large quantities of proteins, their utilization in grazing domains, and their function in increasing worldwide productivity of food and other commodities [1]. Therefore, recent findings have directed towards developing new biological and environment-friendly techniques to enhance the growth efficiency of legumes [1]. Scientists have derived several economic and ecological uses when legumes form symbiotic associations with nitrogen-fixing fungi and bacteria [9]. Biological nitrogen fixation (BNF) within legumes occurs through their association with microorganisms [1]. These microorganisms, which are also needed for the Earth's nitrogen cycle, are utilized for developing agricultural production of plants. Furthermore, they participate in soil colonization and plant growth promotion when utilized in live formulations or biofertilizers applied to seed, root, soil, or the interior of the plant as they can supply large amount of proteins to host cell and enhance soil protection [1]. The need of agroecosystems for nitrogen is assessed through a cost-effective, prospective, and eco-friendly process of biological nitrogen fixation rather than chemical nitrogen fixation. There are several benefits to the process of biological nitrogen fixation. It meets the needs of legumes and intercropped or succeeding crops for nitrogen [1]. This, in turns, avoids or even restricts the application of nitrogen fertilization. Additionally, nitrogen-fixing organisms play an essential role when the amount of nitrogen in the soil is low. They introduce ammonium into the legume biomass to allow faster growing than their plant competitors, but if the protein content is high, nitrogen-fixing microorganisms become alternative to non-fixing species due to high bioenergy cost of nitrogen fixation process [1, 10]. Thus, it can be concluded that nitrogen fixation in legume systems occurs through a variety of physiological and ecological possibilities including the plant's need for nitrogen and the C:N stoichiometry of the ecosystem [1]. It has proven experimentally and theoretically the hypothesis of a feedback control between legume's need for nitrogen and BNF in a specific ecosystem [11].

To enhance the efficiency of the nitrogen fixation process, the most suitable microorganisms for such purpose are selected, and/or genetic engineering of plant species are involved to guarantee high legume crop productivity [1]. Farmers are familiar with the application of commercially available microorganisms (inoculants) that are of great efficiency to nodulate plants and fix nitrogen in the soil [1]. These microorganisms such as rhizobia form associations with legumes in a situation called symbiosis that introduces benefits for both parts [1]. In this scenario, leguminous plants represent the source of energy and photosynthetic products to rhizobia, while rhizobia supplies the legumes with nitrogen in form of ammonium [1, 12]. The symbiosis begins when the roots of leguminous plants are inoculated the rhizobia, which, in turn, form root nodules where BNF occurs with the help of nitrogenase enzyme [1, 13]. In conclusions, several techniques have been developed genetically and biochemically to enhance plant development and crop productivity, suggesting their marvelous importance in improving legumes and other crops [1, 14–37].

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