



Mini Review

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Stimulating Legume Production for a More Sustainable and Nutritious Agriculture

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Abstract

Legume crops are highly valued because of their high grain content of protein and essential amino acids, and other outstanding nutritional properties. The consumption of legumes prevents chronic diseases such as diabetes, obesity, heart ailments and cancer. Also, they are related to sustainable agricultural systems, considering their capacity to associate with atmospheric nitrogen (N) fixing bacteria (Rhizobia), which diminishes the use of synthetic N-fertilizer. In addition, rotating crops with legumes increase the soil quality, and they need less water relative to other sources of proteins. The future of legumes requires the improvement of agronomic practices and breeding new varieties that can cope with the current scenario of climate change, as well as the creation of more nutritional and healthier new legume-based food products.

Keywords: Legumes; Sustainable Agriculture; Drought Tolerance; Health Benefits; Nutritious Food

Introduction

Grain legumes (pulses) are of special importance both from a nutritional and economic point of view due to its presence as staple foods for millions of people worldwide. The legume family (Leguminosae or Fabaceae) encompasses around 12,000 species distributed all over the world and adapted to a large diversity of environments [1], including species such as beans, soybeans, chickpeas, lentils, peas, faba beans, among others. In human nutrition, grain legumes are the key source of plant-proteins and peptides (double or triple that of most cereals), complex carbohydrates and dietary fiber, and a good source of some nutrients such as vitamins like folic acid, essential fatty acids and minerals that have significant health benefits [2]. Farmers have grown pulses for their own consumption using low levels of technology in small-scale agriculture in many places of the world [3-5]. For the agricultural sector, legumes comprise direct opportunities based on the three-P dimensions of global sustainability (Planet, People, and Profit) that have been used to describe the term, implying environmental soundness, social equity and economic growth [6], which is fully applicable to sustainable agricultural systems. Under this context, the current global legume production can be analyzed into five main dimensions:

Scientific

The main limitations affecting the production of legumes are the relatively low increase in yields compared with cereals and the negative effects of biotic and abiotic stress on pulses [7]. Excepting soybean, the production of legumes has been hampered by the lack of varietal protection, especially in developing countries [8], and the limited availability of genomic resources [9]. Unraveling key genetic resources and how plants respond to environmental conditions will allow the development of new strategies for genetic improvement and legume breeding.

Productive

The cultivation of grain legumes is an alternative of crop rotation in farming systems that is highly dependent on the monoculture of wheat and other cereals, and the incorporation of legumes in the crop rotation would allow soil recovery and diversification of production [10], resulting in enhanced soil biodiversity. They improve soil fertility and reduce the problems associated with soil pests and weeds, which is directly associated with productivity gains in the crop rotations [4]. In addition, several legume species are considered low water users such as chickpea, lentil, common



pea, faba bean and cowpea that are recommended for cultivation in arid and semi-arid environments where annual rainfall is low (200 to 400 mm) [11]. For beef, the water footprint per gram of protein is six times larger than for legumes [12]. All these positive productive components of legumes are directly linked to sustainable agricultural systems.

Environmental

Inoculation of legume seeds with Rhizobium bacteria is the natural alternative to reduce or eliminate synthetic nitrogen fertilization [13], and this technique is a widely sustainable farming practice used in many parts of the world. This technology brings benefits because allows the fixation of atmospheric nitrogen in the soil, as a result of the symbiotic relationship between Rhizobium and roots of legumes, a distinctive feature of legumes relative to other plant families [7].

Nutritional

For low-income populations, legumes are staple food providing an inexpensive supply of macro and micronutrients [14], and play an important role in human nutrition since they are a source of protein, energy, certain minerals and vitamins [15]. In addition, legumes are rich in both soluble and insoluble fiber; this dietary fiber is associated with health benefits, especially in relation to cardiovascular disease and digestive disorders [16]. The hypoglycemic effect of the legumes has long been established, in fact, certain legumes (i.e., beans) are known as traditional remedies for diabetes mellitus [17]. Several studies agree that increasing the intake of dietary fiber (soluble or insoluble) induces an increase in postprandial satiety and reduction in subsequent hunger, contributing to body weight control [18]. Pulses also are an important source of proteins that play an important role in human nutrition; in fact, protein rich legumes along with cereals offers one of the best strategies to combat the protein malnutrition [19]. Also, the phenolic compounds represent great potential as functional and nutraceutical ingredients due to the antioxidant and anti-carcinogenic properties [20]. Additionally, legumes provide large amounts of vitamin B complex and are important source of folic acid [21], a valuable micronutrient to human health. Thus, legumes not only are a dietary element that maintains basic nutrition; but is also considered natural functional foods that modulate human health and wellness.

Economic

The main economic impact of the dimensions previously outlined will likely be the recovery of diversity and production of legume crops worldwide. In consequence, and considering that FAO has declared the year 2016 as the "International Year of Pulses" (<http://www.fao.org/pulses-2016/en/>) and that the European community has adopted a shared strategy for the promotion of legume production in the continent [22], it is reasonable to project

a relatively positive global scenario for legume production in the future.

Future Challenges

In a broad prospective, an integrated strategy comprising stakeholders focusing in the use and management of genetic resources, legume breeding, agronomy, genomics and molecular biology, stress tolerance will be useful to tackle the worldwide challenge of guaranteeing food security as increasing resource demands are required to deal with global climate changes [23]. Due to the increasing water scarcity and global climate change in the world, the combination of various biotechnological and agronomic approaches together with advanced genome editing tools is required to release new drought-tolerant legume cultivars [24]. In addition, heat tolerance in the most important legumes cultivated can be improved via several breeding tools, to enhance production in the field. Besides this, omics methodologies can decipher distinct mechanisms explaining the tolerance to high temperatures, which is crucial to gain insight into the molecular responses associated to thermotolerance [25]. In addition, there is presently a value of the selection methods that strengthen the use of existing genetic diversity among pulses to manage the challenges associated with the biotic and abiotic stresses of climate change [26].

Evaluating the yield gaps in rainfed crops such as legumes is also an important challenge for pulses production in the future [27]. To accomplish quicker genetic gains in legumes grown under rainfed conditions, it was suggested that the integration of modern genomics tools, high throughput phenomics, and simulation modelling in favor of legume improvement will result in enhanced cultivars that adapt well with proper agronomic management [5]. The agronomic improvements of legume production are feasible as a consequence of various practices such as early sowing together with minimum tillage, an effective weed control, and the utilization of green manure. Further, crop rotations (i.e., legumes-cereals) enhance nitrogen availability, optimize weed control, and diminish soil disease attack [28]. Consequently, the incorporation of legumes in the crop rotation will diminish greenhouse gas emissions, reduce the utilization of fossil energy, speed up carbon sequestration in soils, and supply a useful source of feedstock for biorefineries, which explain the high value to grow more legumes in the development of future agroecosystems [29].

Finally, there is a demand by the food industry to create a new generation of processed foods that are low-cost, suitable, tasty, and desirable, although they are also sustainable and healthy, in which legumes have an important role to play in the future [30]. Also, efforts must be made by the food industry to create ready-to-eat, attractive, tasty and convenient legume-based food formulations, resulting in the broadening of more nutritional and healthier diets [31].

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