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Common Beans (*Phaseolus Vulgaris L.*)

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Abstract

Among the grain legumes, common beans are the most important for human consumption worldwide. They are produced globally with Latin America being the largest producer and consumer (45% of world production). Per capita consumption in Latin American countries, according to FAO data, is approx. 21kg in Guatemala, 20kg in Nicaragua, 16.1kg in Brazil and 10.1kg in Mexico. In addition to being a source of protein, beans are a source of iron, potassium, magnesium, zinc, fiber, starch, folic acid and thiamine, in significant quantities, which, together with the protein content, makes them an ideal alternative to substitute meats and other protein products. Production statistics in Latin America show marginal growth in common bean production in the past decades, which is due to several reasons; there is a sustained work of genetic improvement, e.g., developing disease-resistant varieties s combined with good yield potential.

Introduction

The Mesoamerican region is considered the center of origin and diversification of beans (*Phaseolus spp*), cultivated and wild [1]. Common beans are currently grown in various regions and conditions, from 0-3,000m a.s.l., mainly by small producers in Central America, Africa and Asia, representing 77% of world production. In Central America, Guatemala and Nicaragua are the largest producers (550 and 390 million kilograms per year, respectively) [2]. The traditional production system of common beans is in monoculture with bush type varieties. However, in the region the system known as Milpa, which consist of an intercropping arrangement (maize-bean) and other vegetables and tubers, is prevalent in the Highlands; irrigation is generally not used, and the crop depends exclusively on rainfall. The dry bean seed, also known as pulse, constitutes one of the primary protein sources for human consumption, providing essential micronutrients such as Iron and Zinc in addition [3,4].

Germplasm collections

The National Plant Germplasm System of the United States of America (NPGS) identifies 81 dry bean species accepted in their online database named Germplasm Resources Information Network (GRIN). This number increases to 117 taxa when including subspecies and varieties. A comprehensive analysis of North and Central American species recognizes no less than 36 species, many of them with one or more subspecies, five of them of economic importance. The Mesoamerican region is considered the main center of origin and genetic diversity of domesticated and wild species of the genus Phaseolus [4-9].

The germplasm bank at CIAT, located in Cali, Colombia, one of the international germplasm banks of CGIAR, operates within the International Treaty Framework on Plant Genetic Resources for Food and Agriculture (TRFGAA). The TRFGAA is primarily funded by the

Platform of Germplasm Banks coordinated by Global Crop Trust. The germplasm bank at CIAT maintains the most important collections worldwide of important crops that provide carbohydrates and protein in the tropical food systems. Beans (Phaseolus species, 37,938 accessions), manioc, cassava, tapioca (Manihot species, 6,155 accessions) and forage crops (22,694 accessions). The CIAT germplasm bank also stores duplicates (security copies) of seeds of world crops in collaboration with the Nordic Gene bank using their underground facilities on the arctic island of Svalbard, midway between Norway and the North Pole, and in the CIMMYT germplasm bank at Texcoco, Mexico [10]. The Institute of Agricultural Science and Technology [11] has national collections of germplasm from different pulse crop species. Additionally, Guatemalan beans are also in the mayor world collection, stored in the germplasm bank at CIAT [12].

Botanical description

Botanically, the genus Phaseolus-including the common bean species (*Phaseolus vulgaris L.*) belongs to the Leguminosae (Fabaceae) family, Faboideae (Papilionoideae) subfamily, Phaseoleae tribe and Phaseolinae subtribe. It is an annual herbaceous plant, and depending on the growth habit, it can reach heights up to two meters [13]. Common beans can present four growth habits: type I determined (bush type), type II indeterminate (bush type), type III indeterminate prostrate and type IV indeterminate climber. Those of determined growth can reach heights between 30cm and 90cm, while those of indeterminate habit reach heights from 50cm to 3m [14].

The bean has a primary root and many secondary roots with nodules developed from an association with the nitrogen-fixing bacterium Rhizobium. The leaves are trifoliate. The flowers have a tubular calyx of five sepals, a papilionoid corolla of unequally sized petals, ten stamens, and a receptive stigma. The flower color can be white, lilac, purple, or bicolored. The fruits are legumes, also called pods, and the seeds have two cotyledons. The seeds inside the pods are rich in protein [15].

Phenology

Common bean presents ten phonological phases during its development, divided into 5 vegetative and 5 reproductive stages: germination (V0); emergence (V1), when the cotyledons appear at ground level; primary leaves (V2), when cotyledons leaf unfold; first trifoliate leaf (V3), when the leaf is entirely unfolded and with the leaflets located in a plane; third trifoliate leaf (V4); flower bud or pre-flowering (R5), when the formation of the first flower bud begins in varieties of determined habit, and when a flower cluster forms in varieties of indeterminate habit; flowering (R6),in the first flowers-in those of a determined habit, flowering begins in the last node of the stem and branches and, in those of indeterminate habit, flowering begins in the lower part of the stem or branches; pod formation (R7), when the first pod appears but the corolla is still visible; pod filling (R8), when the first pods begin to fill up and the active growth of seeds begins; and maturity (R9), when discoloration and drying of the first pods begin, and the seeds are acquiring the shape, solidity and colour typical of the variety [13]. In the determinate varieties, the vegetative development of the main stem stops before flowering, while in the indeterminate it generally ends in stage R8, which is when defoliation also begins [13].

Production and Geographical Distribution

Common beans are produced in diverse systems, regions and environments, e.g., Latin America, Africa, the Middle East, China, Europe, United States, and Canada. In Latin America, it is a traditional and essential food, especially in Brazil, Mexico, Central America and the Caribbean. Estimated data from [16] report an average yield for Mexico, Guatemala, Honduras, and El Salvador of 862.58kg ha^{-1}. Guatemala has the highest yield with 999.1kg ha^{-1} and Mexico has the lowest yield with 728.3kg ha^{-1}. Despite its importance in some countries' the diet, on the world stage, the volume of bean production compared to other grains such as maize, wheat, and rice represents only 1%.

Crop husbandry

Common bean plants are very susceptible to extreme conditions (excess or lack of moisture, pH, etc.), for this reason, it should be grown in well-drained soils with a light texture and a pH that ranges between 6.5 and 7.5 [17]. In smallholders' economy crops such as beans, the growth seasons depend on various factors, especially the weather (rains) and the availability of farm labor. Most farmers do not use irrigation for cultivation and planting mainly takes place at the beginning of the two annual cycles of abundant rainfall, i.e., March and April in the first semester (season A), September and October, in the second (season B). It is recommended growing beans preferably during those times that allow scheduling the harvest in the driest periods, so that both the drying and the best yield quality of the beans are facilitated [18].

The seed represents the form of reproduction and multiplication of the species such as common beans. To ensure the optimal reproduction process, it is necessary to have good quality seed, i.e., seed that will germinate and produce a normal and vigorous plant [19,20]. The beans absorb high amounts of N, K and Ca and in lesser amounts S, Mg and P. Due to the short cycle of the bean crop; fertilization can be done only once at the moment sowing [18]. Integrated pest management is a strategy that tries to maintain the pests of a crop at levels that do not cause economic damage, using preferably adverse natural factors to its development, including natural mortality factors. The application of pesticides should only be considered as a last resort and as an emergency measure [21]. In common beans, methods have been developed for biological control and ethological, among others, of some insect pests and diseases, whose application in integrated form allows for an integrated management strategy [22]. At the time of the harvest, the seeds must have completed their development and have a maximum humidity percentage of 16% [17].

Limitations: Reproductive Needs

Agronomic point of view

1. There are four many commercial types of dry bean [23]. The black bean is mostly consumed in Latin America and the Caribbean. The highest production area (eight million hectares) is found in the Latin American region [24]. However, the common bean production is not increasing as the demands of the exceeding population.

2. Average yield is still low, ranging from 600-1000kg ha^{-1} [25]. Yield is affected by growth stressing environmental conditions such as heat and drought [26]. Besides, diseases and plagues may cause severe production losses; some of them could reach a 100% loss if disease and pest favorable conditions occur.

3. Earliness in most of the varieties is a fact that needs to be overcome in many production areas. Most varieties will take approx. 65-110 days, but some landraces and cultivars may take more than 200 days according to their growth habit [27].

4. Common bean genetic breeding is a solution to many issues but developing the desired variety and the farmer's adoption of the new seed takes several years [23,26].

5. In Latin America, many common bean producers and smallholder farmers in average have two hectares of land to produce this pulse [28]. Common bean production in developing countries is considered ow input and small-scale agriculture [29].

Nutritional point of view

1. Common bean is source of protein from vegetal origin; it also contains vitamins and minerals. Unfortunately, dry beans present anti-nutritional factors that negatively affect human and animal metabolism [30]. Following consumption, the flatulence factor is another issue that creates rejection to this pulse [31,32]. However, nutrition properties for this pulse can be improved by using different processing methods, including soaking, dehulling, germination, fermentation and the use of thermal processing methods [33].

2. The duration of cooking time is related to some landraces and cultivars and other external factors; storage is a critical step to maintain the common bean quality. The lack of humidity and temperature control during storage results in a hard seed coat (test) and/or a hard to cook seed, which requires longer cooking time [34].

Future Prospects

i. Latin America is an important center of diversity of common bean [35-37]. This diversity should be studied for the generation of improved cultivars with better seed yield potential. Common bean is part of Latin American people's basic diet, mainly because it is an essential protein source [38]. The improvement of nutritional aspects through breeding, such as bio- fortification with minerals (iron and zinc) can cause a positive impact on food security. Common bean breeding programs have to focus on the generation of improved cultivars adapted to the different crop systems in Latin America. Their studies should focus on disease resistance and abiotic stress tolerances [26]. Future research should include a strategy that encompasses agronomic features, postharvest management and marketing, since producers in Latin America have limited access to field supplies and facilities for seed storage. These issues directly affect the quality of the product for consumption.

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