Faba Bean- A Future Smart Food

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Feeding the flourishing population in a sustainable way is a global challenge. Industrialization along with the growing population is reducing the per capita land availability thus exerting pressure on arable land to produce more. Climatic stresses like increased temperature, asymmetric changes in night temperature, untimely rainfall are curbing crop yields. In addition to that, shift in population growth of pathogens and pests in relation to the change in climatic factors, is also clutching the yield. Land clearing for crop cultivation is not a sustainable option as it disrupts the ecological balance. In order to provide more food from farm to fork there is urgent need for augmenting the yield of crops on the same unit of lands available and strengthening the existing crop production systems or developing alternative ones. Systematic endeavors are being made to assess the viable alternatives for achieving the balance between the ever-growing population and food production. One of the tactics is to utilize the wide range of neglected and underutilized crop species. Faba bean has been listed as "Potential Future Smart Food" in South Asia and South East Asia under the 'Future Smart Food' initiative by Food and Agriculture Organization (Li and Siddique, 2018).

Origin and Botany

The genus Vicia belongs to the family of nitrogen-fixers, Fabaceae. Most probable origin of Faba bean is the Near East or Mediterranean region while China is the secondary center of origin. The commonly grown genotypes of *Vicia* faba are of three major categories: (a) *Vicia faba* var. *major* (large seeds) (b) *Vicia faba* var. *equine* (medium-sized seeds) (c) *Vicia faba* var. *minor* (small seeds). Large-seeded varieties (broad beans) are extensively being used for food, as a fresh vegetable or (dehulled) dry seeds. Small- to medium-size seeded varieties are mostly used for animal feed purposes.

Faba bean is a diploid (2n=12), annual leguminous crop, which exhibits partial out-crossing. The plant has a straight, sturdy, unbranched stem growing between 0.1 to 2 m tall. It has indeterminate growth habits, and shows susceptibility to lodging. The leaves are alternately pinnate in structure, with two to six leaflets. The flowers exhibit typical papilionaceous pattern, common to all pulse crops, typically white, sometimes with anthocyanin pigmentation on all petals, often the wing petals have black spots. Seeds vary in size and shape, with wide range of colors from yellow, green, brown, black, to violet and sometimes spotted. The plants possess a robust and strong taproot system with profuse lateral root branching, hosting nitrogen-fixing nodules containing rhizobia on both tap and lateral roots. The plant lacks tendrils on the leaves for climbing. Its pods are characterized by being green, wide, and tough, turning blackish-brown with a dense, fuzzy texture when fully mature.

Fig 1: Bud to pod development of faba bean

Benefits of faba bean

Faba bean, a versatile crop with manifold applications ranging from fodder to culinary delights, boasts an impressive array of medicinal properties. The verdant pods of this legume are commonly enjoyed post-cooking, while its seeds find their way to markets fresh or frozen. Renowned for its role as a cornerstone in high-protein, high-energy diets that remain economically accessible, faba bean stands out nutritionally due to its favorable protein-to-carbohydrate ratio compared to its pulse counterparts. Additionally, its amino acid profile aligns closely with the adult nutritional requirements, further enhancing its dietary appeal. Faba bean proteins are mainly globulins, majorly, legumins and vicilins (Boye et al., 2010).

Fig 2: Faba bean plant in reproductive stage

Within its humble exterior lies a treasure trove of nutritional constituents: protein, starch, fiber, minerals, vitamin C, lysine, arginine, isoflavones, and an array of antioxidants and phenolic compounds. Beyond mere sustenance, faba bean serves as a canvas for culinary innovation, with its functional components offering foaming, emulsifying, and gelling properties. These attributes make it a prime candidate for the development of value-added foods and alternatives to traditional meat and dairy products. But the virtues of faba bean extend far beyond the realm of gastronomy. Its medicinal potential is vast, with applications in treating hypertension, cancer, renal failure, anorexia, and a host of other ailments. Particularly noteworthy is its role in combating Parkinson's disease, owing to the presence of L-3,4-dihydroxyphenylalanine (L-DOPA), a precursor to the neurotransmitter catecholamine. This compound, found abundantly in faba bean, has demonstrated efficacy in improving motor function in Parkinson's patients. Furthermore, traditional medicinal practices in regions like Turkey employ faba bean leaves as a remedy for Alzheimer's disease, underscoring its multifaceted therapeutic utility.

Beyond its medicinal and culinary prowess, faba bean plays a pivotal role in agricultural and horticultural systems. Its remarkable ability to fix atmospheric nitrogen surpasses that of other winter pulses, making it indispensable in sustainable cropping practices. Moreover, its robust germination capability endures cold soil temperatures better than most legumes, further solidifying its status as a resilient staple crop. Faba bean thereby transcends its humble origins to emerge as a powerhouse of nutrition, culinary innovation, and medicinal efficacy. From enriching diets with its protein-rich goodness to serving as a potent ally in the fight against debilitating diseases, this unassuming legume continues to leave an indelible mark on both the agricultural landscape and the realm of human health and well-being.

Challenges

Despite being copious in nutraceutical and functional benefits, its use is restricted due to the presence of anti-nutritional factors like vicin, covicine, trypsin inhibitors and condensed tannin. These accumulate in the cotyledons of the beans and on ingestion, they get hydrolyzed into their aglucones, which are the antinutritive and cause favism (hemolytic anemia) (Khamassi et al., 2013). The primary techniques employed to decrease the levels of these compounds in faba bean seeds include soaking, removing hulls, boiling, pressure-cooking, autoclaving, and extrusion cooking.

It also faces a multitude of challenges from both biotic and abiotic sources, which contribute to yield instability. Biotic stresses, diseases including ascochyta blight, chocolate spot, rust, gall disease, orobanche infestation, faba bean necrotic yellow virus, and insect pests such as the black bean aphid, stem borer, pea leaf weevil and broad bean weevil infestation, pose significant threats to crop health and productivity. These pathogens and pests can cause extensive damage to faba bean crops, leading to reduced yields and economic losses. In addition to biotic stresses, faba bean is also susceptible to various abiotic stresses such as waterlogging, drought, heat, and frost. These environmental factors can disrupt normal growth and development, affecting key physiological processes and ultimately impacting yield potential. Waterlogging and drought conditions can hinder nutrient uptake and water absorption, while extreme temperatures, both hot and cold, can cause physiological stress and reduce crop vigor.

Future prospect

Faba bean germplasm, like many other important crop species, is conserved in gene banks around the world to ensure its genetic diversity is preserved for future agricultural use (Karkanis et al., 2018). The International Center for Agricultural Research in Dry Areas (ICARDA) is one of the key institutions involved in conserving and distributing faba bean germplasm, particularly focusing on varieties adapted to dryland agricultural systems. By leveraging the vast diversity within the faba bean gene pool, opportunities for innovation, resilience, and progress in faba bean research, breeding, and agriculture can be unlocked, ultimately benefiting farmers, consumers, and the environment.

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