Research Article

Mungbean (*Vigna radiata* L. Wilczek) as Functional Food, Agronomic Importance and Breeding Approach for Development of Climate Resilience: Current Status and Future Perspectives

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ABSTRACT

Mungbean (*Vigna radiata* L. Wilczek) is highly nutritive food, important feed and fodder crop throughout the world. It is an excellent source of nutrients, minerals and vitamins. Seeds and sprouts of mungbean are commonly used in form of healthy diet. This crop is of particular interest for the countries suffering from low protein diet and mal nutrition. Unfortunately, it is highly sensitive towards climate variability and environmental stress factors. Salinity stress is highly prevailing factor at global level which drastically limiting mungbean production. Huge proportion of arable land has been converted into saline and is continuously increasing every year. Besides this, large population size, deprived availability of nutritious food and lack of improved mungbean varieties against salinity raises serious concern towards food and nutrition security. Small genome size, narrow genetic base and poor exploration of available germplasm for valuable traits further restricts genetic improvement of this crop. In present scenario, the introduction of useful genes from exotic into the cultivated environment through hybridization is more promising to develop climate resilient crops. Presence of bioactive compounds in mungbean providing various health benefits has increased the scientific interest in this crop.

Key words: Mungbean importance, Health benefits, Germplasm, Salinity, Breeding, Food security.

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INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek), is an annual, fast growing and warm-season legume with immense potential. It is generally known as green gram. It has short life span (75-90 days) and small genome size (579Mb) with diploid chromosome number of 2n=2x=22. Mungbean is a low-input crop and it can provide livestock feed as well as green manure. Mungbean was domesticated in India as per the archaeological evidences and genetic diversity data.[1]

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Mungbean belongs to the genus *Vigna*, which comprises more than 100 wild species and 10 domesticated crop species including mung bean, cowpea and azuki bean. Some of their wild relatives have been reported to inhabit extreme environments such as sandy beaches, arid land and limestone karsts.[2] These wild species are expected to harbor important adaptive genes for valuable traits. These adaptive genes could be used for development of stress-resistant crops for agriculturally non-suitable lands. Leguminous crops have greater adaptability towards extreme and harsh environments and contribution towards nitrogen fixation and low-input sustainable agriculture.[3,4]

Mungbean is a creeping annual crop. It can grow extensively on all types of soil but largely sown by the farmers in arid and semi-arid regions. It requires warm climate for seed germination (28-30°C) and better growth performance (30-35°C) throughout the life

cycle. It grows up to a height of 90 cm. Its leaves are alternate, trifoliate and pale green or green in color. The flowers are pale yellow to greenish yellow in color. Fruits of mungbean are known as pods which are pendent, glabrous, linear or cylindrical with a length of 10-14cm. The color of the pods varies from greenish brown to black. Each pod constitutes 10–15 number of ellipsoidal green, yellow to brownish or black mottled seeds.[5]

India is the biggest producer, importer and consumer of pulses in the world. During 2017-2018, the production of mungbean recorded was 2.01 Mt over an area of 4.26 Mha with an average grain yield of 472 kg/ha. More than 80 per cent of mungbean production comes from 10 major states of India as Rajasthan, Maharashtra, Madhya Pradesh, Karnataka, Bihar, Andhra Pradesh, Odisha, Tamil Nadu, Gujarat and Telangana. But the import of pulses has declined from previous year during 2017-2018 resulting in savings of national economy. Farmer-friendly policy measures have helped to reduce this import of pulses. Recently, the Cabinet Committee on Economic Affairs has approved the proposal for the removal of prohibition on export of all types of pulses. This ensures the farmer's own choice in marketing their produce and in getting better remuneration for their produce. It also encourages the farmers to expand the area of sowing of pulses.[6,7]

Nutritional, Agronomic and Economic Importance

Mungbean has been consumed in form of common traditional food worldwide.[8] It is a good source of protein, folate as well as iron in comparison to other legumes.[9] The seeds of mungbean constitute protein (24-28%), oil (1.0-1.5%), ash (4.5–5.5%), fiber (3.5-4.5%) and carbohydrates (62–65%) on dry weight basis. The protein in the mungbeans contains a better quantity of essential amino acids, including leucine, phenylalanine, valine, isoleucine, tryptophan, methionine, arginine and lysine.[10] During sprouting, the proteolytic cleavage of proteins, minerals, amino acids and vitamins are significantly high. This valuable crop constitutes an important place in vegetarian diets because of its high and easily digestible protein. Mungbean is also considered as quality pulse which provides nutritional balance in cereal-based diet of the people in South Asia and Southeast Asian countries. It improves soil fertility and texture due to fixing of atmospheric nitrogen via root rhizobial symbiosis.[11] Low input requirement, short crop duration along with high global demand make mungbean an ideal rotation crop in rice based cropping system. Hence, cultivation of mungbean generates triple benefit including additional income with nutrient-rich food, and increased soil fertility. Moreover, intercropping of mungbean increases the yield of the subsequent cereals and reduces the requirement of nitrogen fertilizers and pest incidence.[12,13] Various important characteristics of mungbean are shown in Figure 1.

Mungbean as Functional Food: Health Benefits

Consumption of mungbean along with cereals is continuously increasing due to its easily digestible proteins, palatable taste and soluble carbohydrates with low flatulence.[14,15] Besides this, mungbean seeds and sprouts produce low number of calories as compared to other cereals. Various health benefits have been assigned to consumption of mungbean. Germination of seeds significantly enhances the nutritive value and medicinal qualities of mungbean.[16,17] This valuable crop also possesses phytic acid, tannins, hemagglutinin, trypsin inhibitors and other anti-nutrients involved in various biological activities. Regular intake of mungbean sprouts in diet helps in maintaining the beneficial microbial flora in the gut, and reduces the absorption of toxic compounds.[18,19] Therefore, it prevents various metabolic disorders.[18,19] Recent studies have been reported various bioactive compounds in mungbean seeds, seed coat, sprouts and leaves having health-promoting effects (Figure 2) on human.[5] This includes organic acids, flavonoids, phenolic compounds (vanillic acid, gallic acid, caffeic acid, cinnamic acid, protocatechuic acid, shikimic acid, and p-hydroxybenzoicacid). These compounds are well

Figure 1: Characteristics features of mungbean.

known for their detoxification, antiscorbutic, diuretic, antihypertensive, antipyretic, anti-dote and anti-cancer properties.[20] These are used to alleviate heat stroke, regulation of gastrointestinal problems, treatment of alcoholism, moisturization of the skin, reduction of ache, heat, hypertension and inflammation.[21-23] It has been also reported that mungbean paste of can treat acne, eczema, dermatitis and relieving itchiness. Several studies in India also highlighted the use of mungbean seeds for piles, paralysis, fever, cough, liver diseases, rheumatism, and nervous disorders or diseases. The roots of mungbean have sedative property and effectively used in bone aches.[24,15]

Genetic Resources of Mungbean

Mungbean genetic diversity is preserved in various germplasm collection units world wide. The major collection centers are maintained at Philippines, Taiwan, China, India and USA.[25-27] The available genetic diversity at these centers can be used for enlargement of genetic base of mungbean cultivars. In general, screening of large collections for desired traits is economically and logistically challenging.[28] Also this procedure is laborious and costly for most breeding programs.[28] Establishment of subsets of large germplasm collections can make screening more practical.[29] Mungbean core collections were established in India, China, USA and Korea. Core collections facilitate access to genetically diverse germplasm and also trait diversity.[29]

Climate Change and Food Security

Legumes are important food crops with high nutritive value. But the production of food grain legumes particularly, mungbean is drastically reduced due to various abiotic and biotic stress factors existing in the environment, climate variability and climate-related disasters (extreme heat, drought, frost, floods, storms) which are continuously increasing with population size worldwide. These factors harm agricultural productivity which limits sufficient food availability.[30,31] This may leads to severe food crises at global level.[31] Among abiotic stress factors, increasing salinity (1-3% per year) is among the major problems towards sustainable agriculture production of mungbean specifically in arid and semi-arid regions.[32] Around 6.73 million ha area of arable land is affected from salt in India only.[33] The problem related to poor quality water is continuously increasing in some states of India namely Rajasthan, Haryana and Punjab.[33] This happened due to increase in irrigated area and exhaustive use of natural resources to get the food and other requirements for life of rising population.[33]

All soils invariably contain soluble salts. But the sulphates and chlorides of calcium, sodium and magnesium are the dominated soluble salts in saline soils.[34] Salinity can be developed either naturally (primary salinization) or from interferences in the water cycle (secondary salinization) which causes accumulation of excess of salts in the root zone. This causes frequent deterioration of biological, chemical and physical properties of the soil.[33] Moreover, the poor drainage systems for the leaching and removal of excess salts also increases the problem of salinity in India.[31,34] Plants grown in such soil fail to absorb sufficient nutrients and water for

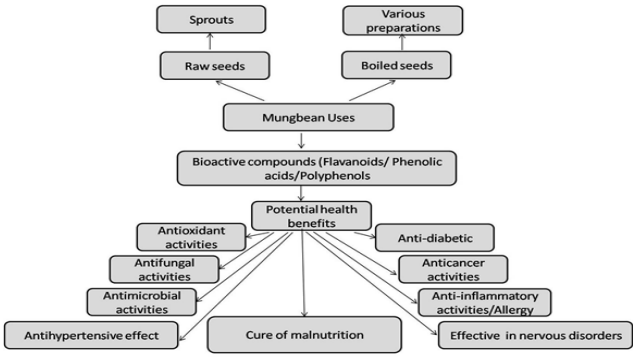

Figure 2: Health benefits of mungbean.

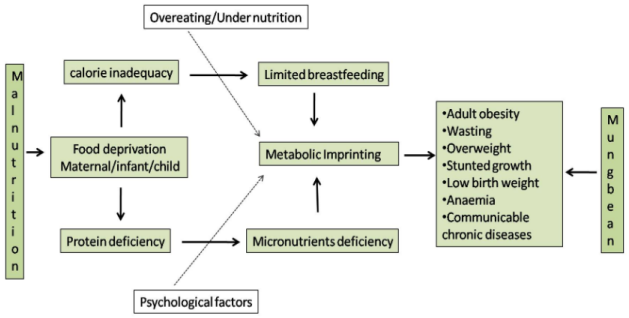

Figure 3: Different forms of malnutrition.

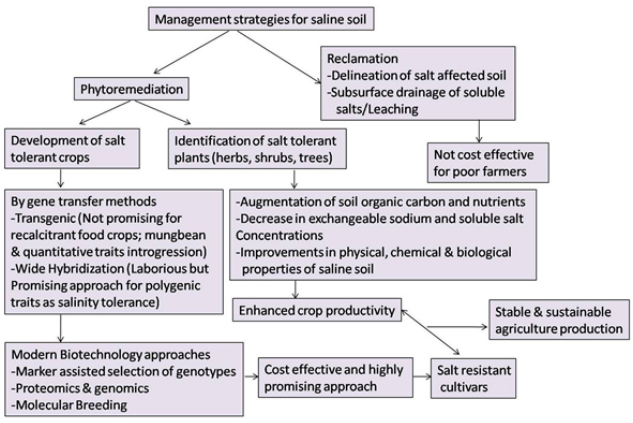

Figure 4: Approaches to manage salt affected soil for enhanced food production.

normal growth and development. These hurdles cause reduction in production and productivity of the crop plants.[32-34]

Salinity affects most of the growth stages of plant development including germination of seeds, vegetative growth, and also reproductive development along with yield attributes.[35-38] Osmotic balance maintenance is crucial for the plants growing in saline medium. Failure in the osmotic homeostasis under salinity results in dehydration at cellular level. This dehydration is due to loss of turgidity which results in cell death. Osmotic stress along with ion toxicity cause metabolic inequity, which in turn leads to oxidative stress due to buildup of reactive oxygen species. Excess salts in soil profile degrade the soil structure and lead to poor-spotty stands of crops, having uneven and stunted growth, chlorosis and necrosis in leaves, poor yields along with presence of white crusts at the surface depending on the extent of salinity.[39] Plants growing in salt infested areas may have smaller, darker blue-green colored leaves than the normal leaves. The factors responsible for the development and/or accumulation of soluble salts in soils includes: 1) weathering of rocks, 2) continuous irrigation with groundwater, 3) excessive leaching of salts, 4) seepage from canals, 5) congestion of natural drainage, and 6) localized redistribution of salts and water logging/ faulty irrigation practices.[34]

Severe deterioration in environmental health, depleting energy reserves prevalence of hunger and malnutrition are the big risks to the sustainable human life.[30,40] A large portion of population in several regions of Africa, Asia and Latin America are experiencing chronic undernourishment. The number of undernourished people is still high in most parts of South Asia. India hosts the second highest estimated number of undernourished peoples in the world.[41] Limited food availability also causes hikes in food prices and loss of income which makes the poor people dependent on more caloric and unhealthy food products. Poor nourishment to the infants or children raises the serious concern of malnutrition in developing countries.[42,43] Non availability or poor access to healthy and nutritious food to the pregnant women or to the children causes atrocious alterations in metabolic pathways, physiological responses and neuroendocrine signaling mechanisms in children that power intergenerational cycle of malnutrition (Figure 3). These changes further results in imbalance between nervous system and metabolism which is responsible for occurrence of various nervous disorders and chronic diseases later in life. There is great need to focus on identification, development and rising of more nutritious food crops as mungbean by the breeders or researchers involved in crop improvement against climate change. Development and refinement of appropriate technologies for recovery and management of salinity affected arable land seems promising option to achieve nutritious food security (Figure 4) in near future.[31,32,44]

Breeding Approach for Development of Climate Resilient Crops

India is rich in genetic diversity of major pulse crops including mungbean.[45,46] Wild and exotic germplasm are new sources of variability for agronomic traits which is not found in the cultivated species. Study of genetic diversity among crop species and their phylogenetic relationship play significant role to predict interspecific or intra-specific cross compatibility for breeding practices.[47,48] Exploration of unidentified mungbean germplasm and their wild *Vigna* relatives from several gene banks should be explored at molecular level to enhance the genetic diversity in mungbean. It may help in broadening of genetic base of mungbean and to identify novel genetic resources for breeding against environmental stresses.[49,50] The complete genome sequence of mungbean efficiently facilitates the molecular breeding approaches to develop elite cultivar of mungbean for salinity affected areas.[51,52] Several new recombinants having desired traits (agronomic) and different cultivars with improved characteristics have already been developed through hybridization using germplasm resources which are finding popularity in farmer's fields across different cropping situations. Interspecific hybridization is among the most efficient and reliable strategy to introduce useful traits of wild crop species in to their relative cultivated crops.[32,53-55]

CONCLUSION AND FUTURE PERSPECTIVES

Mungbean is an important food grade legume with high nutrition status and great pharmacological potential. It is an ideal crop of farmer's interest and vegetarians. It plays diverse role in agricultural systems as well as food sector. The seeds of mungbean are generally consumed in processed forms or directly in form of germinated sprouts in developing countries. Thus, research on legume crops may have a significant role in nutritional security and soil health in a long term basis. The agriculture and food systems require becoming more efficient, sustainable, climate smart and nutrition sensitive. Identification and development of climate resilient (salt resistant) mungbean cultivars should be on priority for the people involved in improvement and sustainable production food grain legumes.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUMMARY

Mungbean is an important short duration leguminous crop. It has great nutritional, agronomic and pharmacological significance. But the production of this crop is adversely limited by cumulative effects of various biotic and abiotic stress factors prevailing in the environment. Presently, there is a great need to develop resistance against these factors in mungbean using modern biotechnological approaches for enhanced and sustainable mungbean production.

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