

Review Article

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Nutrient-Rich Beans with Benefit (*Vigna radiata* (L.) Wilczek): A Review

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ABSTRACT

Mung bean (*Vigna radiata* (L.) Wilczek), commonly known as greengram, is a significant grain legume crop cultivated across the globe and is native to India. It is the most useful pulse crop having an economic significance towards the nutritional security and sustainable agriculture. As it is rich in vitamins, minerals and proteins which are easily digestible, it is an inseparable ingredient in Indian diet when supplemented with cereals particularly rice. It assimilates the atmospheric nitrogen with the Rhizobium bacterial symbiotic association. It subsequently provides the requirement of nitrogen for itself and the next crop in that particular land. It is a short duration crop and due to its photo and thermo insensitive characteristics, it is generally used for crop diversification and crop intensification purposes. A seed of mungbean is highly nutritious for human consumption. It contains edible proteins, fats, fibers and carbohydrates. Mungbean is a tropical legume widely cultivate in the subtropical climatic conditions across the globe. It can tolerate dry land condition for cultivation and decrease the depletion of soil nutrient status. It is constantly used as a fodder crop and a green manuring crop since decades. This review aims to highlight the importance of greengram as a crop in the context of food security, improvement of its agronomic characters and the progress on the recent research and development to explore its genetics using recent developed biotechnological tools.

Keywords

Mungbean,
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Introduction

Mungbean (*Vigna radiata* L. Wilczek) is one of the economically important pulse crops. It belongs to the subgenus Ceratotropis and is having a diploid genome with $2n=22$. This crop is of minor importance with constrained spatial distribution and has watchfully been employed in cytogenetic experiments. On account of quality protein and minerals

contain, this crop is commonly taken as a balanced diet in India. Precisely when improved with oats, they give a perfect mix of essential amino acids with high biological importance. In symbiotic association with Rhizobium, mungbean can assimilate atmospheric nitrogen and enables the criteria to meet the essential nitrogen requirement of its own along with the succeeding crops (Ali, 1992). In India, when it is grown between

wheat and rice precisely, it gives around 33 - 37 kg nitrogen (N) per hectare for the succeeding crop. It has also been reported that, these crops have a smooth weed flora of (20-45%) when used as an intercrop with tall cereal crops (Ali, 1992) and consequently sustain the cost of weed control.

On dry weight basis, the highly nutritious seeds of mungbean contain around 24-28% easily digestible protein, around 1.5% fat content, 3.5-4.5% fibre content, 4.5-5.5% ash content and 59-65% carbohydrates content (Tsou *et al.*, 1979). Mungben seeds provide 334-344 kcal energy when supplemented with rice (Mehandi *et al.*, 2019). The haulms of mungbean are traditionally used for fodder. The beans and husks of the mungbean have a great utility for cattle feed purposes. Also the greengram crops are cultivated for hay, green manure and cover crop purposes. As the stems and leaves of mungbean are comparatively less hairy, it yields better hay content than uradbean. In the present situation, for 95% of the caloric intake in the daily basis, the global food supply chain is based on thirty different food crops out of which 60% of the caloric intake in daily basis is supplemented by mostly four important crops *i.e.*, rice, wheat, maize and potato including some minor crops. Across the globe in the context of mungbean production, only the continent Asia accounts for 90% with an average yield of about 400 kg per hectare (Mehandi *et al.*, 2019).

To human diet, mungbean supplies necessarily significant amount of carbohydrates and proteins as it contains lysine which is an essential amino acid generally lacking in cereals. Though it is having a poor quantity of methionine, the beans contain the high level of free radical activity (Mehandi *et al.*, 2019). Sprouts of mungbean are the rich source of vitamins and minerals. The production time of the sprouts

is less and these are generally marketed as fresh sprouts or in processed form. Mungbean production increases the income of the farmer through the sale of the beans either in fresh or processed form. The cultivation of the mungbean also reduces the farm inputs after cultivation (Mehandi *et al.*, 2019). In many relevant cases, these minor crops like greengram are grown for staple food purposes, contributing to the global food supply. Therefore, this review aims to outline the status on mungbean towards the resistance breeding for the biotic and abiotic stresses to increase its yield and its potential contribution towards the global food security that could increase farmer's income.

Origin and ecology

The mungbean is native to north eastern India. According to the morphological evidence, researchers have considered that, var. sublobata is the progenitor of mungbean. The detailed studies on wide collections of var. sublobata and its breeding behavior suggested that the var. sublobata is a polymorphic taxon with two distinct morphological groups and can be designated as *Vigna radiata* var. sublobata (Rachie *et al.*, 1974). The wild collections have characteristics like annual growth habit, erect plant type, photoperiod insensitivity, more pods with high number of seeds, and smaller leaves. The present day cultivars of mungbean might have emerged from new combinations of the already existing variants, changes in growth habit and seed size have been brought about by possible accumulation of recessive mutant genes. Mungbean is a tropical grain legume crop typically cultivated in the subtropical countries. This legume performs excellent in loamy soils with an annual rainfall of about 750-900 mm. It is resistant to drought and susceptible to water logging. It is grown in kharif, winter and summer seasons in different agro-ecological conditions. It is a

very useful intercrop during the cultivation of crops like sugarcane, maize, cotton, groundnut, sorghum and pigeonpea during kharif season. While during winter season, it is cultivated as a relay crop with the cereal crop particularly rice and cultivated as a catch crop during summer season or spring season.

Historical frame of reference

In 1948, a promising variety, Type 1, was released to cultivate in UP and it was a locally selected germplasm from Bihar. During the period from 1948 to 1970, some important varieties of mungbean, Co 1, ADT 1, Jalgaon, Khargone 1, Krishna, G 65 were developed for cultivation through selection procedure. In 1972, Jawahar 45 (Hybrid 45) was released for cultivation in Madhya Pradesh and in 1972, Type 44 was released for cultivation in Uttar Pradesh. Probably, these two varieties were the first two varieties developed through hybridization. A variety named Virat was released by ICAR-IIPR, Kanpur with 55 days of maturity characteristics. It is recommended for rice-wheat cropping system. Type 1 has been used afterward as one of the parents in hybridization programmes for the development of improved varieties like Type 2, K 851, T 44 and Sunaina. Utilization of T 44 in hybridization has resulted in the development of Pusa Baisakhi which, in turn, has given PIMS 4 and Jyoti. Through mutation breeding procedure, about 14 varieties have been developed using gamma rays or EMS (Ethyl Methane Sulphonate) as mutagens and the varieties developed through mutation are CO 4, Pant Moong 2, TAP 7, BM 4, MUM 2 and TARM 1 (Mehandani *et al.*, 2019).

Production constraints and research needs

The significant limitations in the way to accomplish high return are absence of reasonable hereditary changeability,

nonappearance of commendable ideotypes for different cropping system and cropping patterns, biotic and abiotic stress susceptibility and non-accessibility of viable seeds. The significant yield restricting variables are seedling vigour, excessive flower production, flower drops, poor pod setting, poor harvest index, monocarpic senescence, low response to inputs, narrow adaptation, indeterminate growth habit, staggered maturity and sensitivity to photoperiods and temperature.

During kharif season, mungbean yellow mosaic infection (MYMV) and during spring season cercospora leaf spot disease caused by *C. canescens* are the significant disease infections which cause severe yield loss to mungbean. During the vegetative stage, defoliation caused by defoliators like semi-looper and hairy caterpillar are the important pests which cause yield loss. Action of thrips begins at the bud stage and poses difficult issues when the yield accomplishes top blossoming, bringing about substantial bloom drop. There is no resistant variety against these insect pests.

Varieties developed in the past with resistance to single stress may not be a viable solution as new diseases and insect pests are emerging leading towards pest resurgence. Therefore, varieties having resistance to more than one stress provide greater crop insurance towards the biotic stresses.

For mungbean, high yielding cultivars with crop duration of 85–90 days for kharif season and 65–70 days for spring season with decreased photoperiod affectability are required. For summer season, early varieties of 55–60 days are suitable for cultivation. In recent practice, large seeded varieties like Pusa Vishal, SML 668, TMV 37, and so forth have been created which have extraordinary market value.

Qualitative trait genetics and mapping of genes or QTLs

Information on the genetics of some unusual traits in a crop is crucial to design its breeding programmes. Qualitative traits are responsible for the major agronomic characters which directly impact on the yield parameters. Several studies have been conducted to know the genetics of qualitative traits of greengram, which are presented in Table 1. Genetic diversity assessment utilizing the random RAPD markers shows close relatedness and similarity among mungbean accessions. The investigation uncovers restricted narrow genetic hereditary base of Indian cultivars presumably due the repeated use of limited ancestors in their pedigrees. This perception has additionally been affirmed utilizing RAPD (Betal *et al.*, 2004; Afzal *et al.*, 2004) and ISSR (Sinha *et al.*, 2004; Saini *et al.*, 2004) markers.

AFLP markers have additionally been utilized in mungbean to investigate the genetic diversity of mungbean germplasm (Ghat *et al.*, 2005). The long primers yielded altogether higher number of discrete and recognizable groups just as polymorphic groups than 10-base primers. The outcomes show that long primers can be utilized proficiently for breaking down hereditary decent variety and the connections in mungbean germplasm. Expanding the seed weight has been one of the significant goals to grow high yielding assortments. RFLP markers are used to find major QTLs for the seed weight in mungbean (Mehandi *et al.*, 2019). Studies on the hereditary connection between hard seededness and seed weight, be that as it may, are not indisputable. QTL mapping approach (Table 2) utilizing molecular markers have been utilized to examine the linkage connection between some genes or QTLs with remarkable traits having economic importance towards

greengram cultivation and achieving a good yield.

Breeding approaches and crop improvement strategies

The breeding strategies to develop disease resistance high yielding greengram varieties are generally included the traditional breeding methods like wide hybridization, pedigree selection, pureline selection and mutation breeding strategies. Major emphasis should be given to the short durability, photo-thermo insensitivity, synchronous maturity and MYMV (mungbean yellow mosaic virus), powdery mildew disease and CLS (*Cercospora* leaf spot) resistance while experimenting on selection procedure. More than 150 accessions have been developed so far in India by employing pure line selection procedure and pedigree selection followed by hybridization (Mehandi *et al.*, 2019). Mungbean is adapted to tropical and subtropical lowlands for extensive cultivation.

It is relatively tolerant to abiotic stresses, like drought and heat stress but its productivity is affected by soil salinity. Along with the greengram plants in the field in standing condition, soil salinity interferes with symbiotic microorganisms associations such as *Rhizobium* sp. which is essential for biological nitrogen fixation resulting growth and yield reduction (Wati *et al.*, 2017). Salt tolerant mungbean crop species, such as *V. marina* (sustain in highly saline conditions) may not be suitable to cross with mungbean due to which these are not available for breeding for salt tolerant varieties development (Chankaew *et al.*, 2014). Mungbean yellow mosaic disease is one of the most important growth limiting biotic factor in mungbean cultivation. Against yellow mosaic virus disease, moderate resistance has been found in the gene pools of mungbean, but this is not sufficient enough to explore resistant varieties.

Table.1 Genetics of qualitative traits in greengram

Traits	Characteristic features	Genes involved	Reference
Growth habit	Indeterminate, Erect, semi-erect, semi-spreading or twining type	Single dominant or dwarf mutant gene involved	Siddique <i>et al.</i> , 2006, Khattak <i>et al.</i> , 2002, Pathak <i>et al.</i> , 1963, Pande <i>et al.</i> , 1988, Talukdar <i>et al.</i> , 2003
Pigmentation	Anthocyanin and purple pigmentation in hypocotyl, epicotyl, stem and petiole	Single dominant genes (Pppl) involved	Pathak <i>et al.</i> , 1963, Rheenen <i>et al.</i> , 1965, Mishra <i>et al.</i> , 1970, Dwivedi <i>et al.</i> , 1985
Leaf size	Pentafoliate, Ninefoliate, Narrow lanceolate leaf, Trilobite leaf	Single recessive, 2 recessive gene (nil, n12), 2 dominant gene (T1b1 and T1b2) involved	Dwivedi <i>et al.</i> , 1985, Chhabra <i>et al.</i> , 1990, Bhadra <i>et al.</i> , 1991, Sareen <i>et al.</i> , 1985
Stem fasciation	Stem fasciations on floral organs	Single recessive gene (fsl) involved	Dwivedi <i>et al.</i> , 1990
Infloroscence	Number of clusters per node	Single dominant gene involved	Singh <i>et al.</i> , 1995, Saini <i>et al.</i> , 1974
Flower colour	Petal colour (red, yellow, olive yellow)	Single dominant gene involved	Bose <i>et al.</i> , 1939, Murty <i>et al.</i> , 1972
Pubescence	Dense plant pubescence	Single dominant gene (Dp) involved	Murty <i>et al.</i> , 1972
Pod colour	Black or brown mature pod	Single dominant gene involved	Siddique <i>et al.</i> , 2006
Pod shattering	Dominant	Single gene involved	Singh <i>et al.</i> , 1975
Seed coat colour	Black, brown, green and yellow	4 genes involved (Two Complementary)	Watt <i>et al.</i> , 1977, Mehandi <i>et al.</i> , 2013
Seed coat	Dull and rough	Single dominant gene involved	Siddique <i>et al.</i> , 2006
Cotyledon	Green colour	Single recessive gene (gc) involved	Thakare <i>et al.</i> , 1980
Seededness	Hard seededness	Single dominant gene (Hdl) involved	Lambrides <i>et al.</i> , 1996
Photoperiod	Insensitive response	Single recessive gene involved	Verma <i>et al.</i> , 1971

Table.2 Genes or QTLs mapped for some remarkable traits in greengram

Trait	Marker	Genes or QTLs and map distance	Reference
Seed weight	RFLP	Identification of a Major QTL, association between seed weight and hard seededness (Mapping Population F ₂), 4 loci for hard seededness	Lambrides <i>et al.</i> , 1996, Fatokun <i>et al.</i> , 1992, Humphry <i>et al.</i> , 2005
CLS resistance	SSR	First time QTL mapping for CLS resistance in mungbean (qCLS) located between markers CEDG117 and VR393	Sompong <i>et al.</i> , 2010
PW resistance	RFLP	Genes, ‘13 m’ and ‘Thiz2’ identified in a cross population VC3890 × TC1966 and Identification of Two QTLs, ‘13MR1’ and ‘PMR2’	Sahli <i>et al.</i> , 1979, Chaitieng <i>et al.</i> , 2003
Bruchids resistance	SNP	Major resistance QTL mapped on cr no. 5	Schafleitner <i>et al.</i> , 2016
Domestication purpose	SSR	Total map distance of 727.6 cM	Isemura <i>et al.</i> , 2012
MYMV resistance	SNP	Total map distance 1291.7 cM	Mathivathana <i>et al.</i> , 2019

(RFLP – Restriction fragmented length polymorphism, SSR – Simple sequence repeats, SNP – Single nucleotide polymorphism, CLS – Cercospora leaf spot, MYMV – Mungbean yellow mosaic virus, QTLs – Quantitative trait locus, cM – Centmorgan, PW - Powdery mildew, cr no. – chromosome number)

Studies suggested that, mutation breeding in mungbean resulted a certain significant level of resistance against yellow mosaic disease using the hybrids accessions and moderately resistant accessions of mungbean (Ashraf *et al.*, 2001).

The resistance line NM94 (derived from mutation breeding) is now registered for yellow mosaic disease and now recommended for cultivation because of its high yielding criteria. ML1628, a variety which is found resistance to multiple strains of the virus causing MYMD, was released from Punjab Agricultural University (PAU), Ludhiana, India (Nair *et al.*, 2017). Major store grain pests of mungbean like Bruchids (*Callosobruchus* sp.) lay their eggs on pods when the crop is in the standing condition in the field, which after hatching can destroy all

stored mungbean grains (Lambrides *et al.*, 2000) during storage. Marker-assisted selection (MAS) is a relevant aspect regarding mungbean breeding and now a days, genome-wide association mapping is an important biotechnological tool to map the genes which are linked to some important agronomic traits. But, though mungbean is a minor crop, low funds inputs limit the population size for phenotypic analysis and ultimately result the mapping of simple oligogenic or monogenic traits. Examples of some important traits recently mapped in mungbean are tolerance to drought and high heat stress (Liu *et al.*, 2017), development in seed starch content (Masariet *et al.*, 2017), salinity tolerance (Chankaew *et al.*, 2014), resistance to powdery mildew disease (Poolsawat *et al.*, 2017), yellow mosaic virus disease (Singh *et al.*, 2017), and bruchid resistance (Schafleitner *et al.*, 2016,

Kaewwongwal *et al.*, 2017) which needs further validation experiments.

In conclusion, mungbean has the distinct benefit having a short crop duration. This truth in conjunction with its environmental nitrogen fixing capability makes it a vital source in numerous cereal-based cropping systems and cropping patterns. Proper evaluation is needed to establish a successful breeding strategy and utilization of germplasm assets from secondary and tertiary gene pools by way of conventional and biotechnological tools for development of its agronomic traits. Incorporation of genes from its nearly related species for resistance or tolerance to biotic stresses like MYMV, bruchids and abiotic factors like sensitivity to photoperiods, high temperatures, drought, waterlogging, pre-harvest sprouting and nutrient use efficiency. Breeding for fixation of atmospheric nitrogen should be prioritized. The lack of development in salt tolerance of mungbean needs extra attention in the research. Knowledge gaps on breeding in opposition to economically critical pests and diseases have been addressed in the latest past. However, each issues want to be taken into consideration by way of countrywide breeding program followed with novel breeding approaches. Additionally, extra emphasis is required on exploring mungbean to combat hidden starvation by linking it to national food policies.

Conflicts of interest

All authors declare there is no conflict of interest among them.

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