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Abiotic and Biotic Stresses in Green Gram (*Vigna radiata* L. Wilczek): A Comprehensive Review

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ABSTRACT

Green gram (*Vigna radiata* L. Wilczek), a vital legume crop widely cultivated across Asia, is a rich source of minerals and plant-based protein. Despite its nutritional and agricultural importance, green gram production is significantly affected by various biotic and abiotic stress factors. Biotic stresses include diseases caused by bacteria, viruses, fungi, and insect pests. Major fungal diseases impacting green gram are *anthracnose, cercospora* leaf spot, and dry root rot, while viral infections are predominantly caused by the yellow mosaic virus. Insect pests such as bruchids, aphids, jassids, and whiteflies also pose serious threats to crop health. Abiotic stresses, particularly salinity, high temperatures, and drought, are equally detrimental and are becoming increasingly prominent due to climate change. These stressors adversely affect plant growth,

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development, and yield, posing a significant challenge to sustainable green gram production. Understanding the physiological, biochemical, and molecular mechanisms of stress tolerance is essential for developing resilient green gram cultivars. To mitigate the adverse effects of these stressors and ensure sustainable production, integrated crop management strategies are crucial. These strategies should encompass genetic engineering, traditional breeding, marker-assisted selection, and improved agronomic practices. Genetic approaches can help develop green gram varieties with enhanced resistance to both biotic and abiotic stresses. Additionally, agronomic practices such as optimal irrigation, soil management, and the use of bio pesticides can further support stress management. This comprehensive review highlights the critical need for a multifaceted approach to manage biotic and abiotic stresses in green gram. By integrating advanced genetic techniques with sustainable agronomic practices, it is possible to enhance the resilience and productivity of green gram, ensuring its continued contribution to global food security.

Keywords: Biotic stress; abiotic stress; resilient; markers; diseases; insect pests.

1. INTRODUCTION

Mungbean/Green gram (*Vigna radiata* L. Wilczek) stands as an important leguminous grain widely grown in the tropical and subtropical regions of the subcontinent of India, valued for its edible seeds and sprouts with are rich in protein [1]. Mungbean is favored for its easy digestibility and flatulence-producing factors are absent, making it a crucial component in the diets of poor populations [2]. However, its seeds are deficient in sulphur amino acids, specifically methionine and tryptophan, while exhibiting high lysine content. To address this nutritional imbalance, combining mungbean with cereals in the diet is advocated to ensure a more balanced amino acid profile [2]. Additionally, mungbean seeds are rich in Ca, K, and vitamins (riboflavin, and niacin, thiamine), and notably high in iron [3-6]. The recently developed variety Pusa bold-1 (Pusa vishal) contains 6 mg of iron per 100 g raw seeds compared to traditional varieties [7]. The bioavailability of iron is enhanced when seeds are cooked with specific vegetables such as tomato, mustard greens, and cabbage, showing potential benefits in addressing iron deficiency, especially in anemic school children [8,9]. Beyond its nutritional contributions, mungbean plays a versatile role in agriculture. As a short-duration crop, it acts as a biological nitrogen fixer in the soil, which acts as a cover crop to mitigate soil erosion and is occasionally utilized as fodder and green manure [2].

Beyond its nutritional contributions, mungbean plays a versatile role in agriculture. As a short-duration crop, it enriches soil fertility through biological nitrogen fixation, acts as a cover crop to mitigate soil erosion, and is occasionally utilized as green manure and fodder [2]. In the global context, mungbean's importance extends beyond the Indian subcontinent. With approximately 7.3 million hectares of cultivation worldwide, India and Myanmar jointly contribute 30% to the global production of 5.3 million tonnes. Despite India contributing approximately 75% to the world's mungbean production, the crop faces challenges in yield improvement. Diseases, notably yellow mosaic virus, powdery mildew, and *cereospora* leaf spot, alongside destructive insect pests like bruchid beetles (*Callosobruchus* spp.), pod borers (*Heliothis armigera* and *Maruca testulatis*), contribute to significant yield losses [10]. Chemical control measures have proven expensive and ineffective, leading to ecological concerns and the emergence of resistant insect biotypes. Traditional breeding approaches for disease and pest resistance have faced limitations due to the low levels of resistance in wild relatives of mungbean [11]. The crop also grapples with sensitivity to salt stress, indeterminate growth habits, and other factors limiting yield.

2. CONSTRAINTS FOR PRODUCTIVITY

The main factors contributing to the low productivity of mung bean in India are the limited adoption of improved varieties and technologies, insufficient and untimely availability of high-quality seeds and other inputs, water scarcity caused by reliance on rainfall, extreme temperatures, susceptibility to pests and diseases, and cultivation on low-quality and unproductive land. The cultivation of the crop, which rely solely on rainfall (87%) and are planted on low-quality and less productive grounds, often faces challenges from both living organisms and environmental factors.

Drought and heat stress are abiotic factors that can significantly decrease seed yields, particularly in arid and semi-arid areas. This reduction can reach up to 50% as shown in Table 1. The inadequate drainage and waterlogging that occur during the rainy season result in significant damage to the crops [12]. Another significant issue is the high levels of salinity and alkalinity found in soils, which are prevalent in both semi-arid tropical regions and the Indo-Gangetic Plains (IGP). In terms of biotic stressors, insect pests, diseases, and weeds negatively impact the production of pulses. In India, Pande [13] found that diseases alone cause a loss of 10-15% in production. This highlights the pressing requirement to develop technologically possible and economically viable agricultural technology to address these abiotic and biotic challenges, while ensuring the sustainability of increased crop yields and profitability. Various abiotic and biotic stress in green gram illustrated in Fig. 1.

2.1 Abiotic Stresses

Abiotic stresses are primarily unavoidable and are the most harmful factor concerning the growth and productivity of crops, especially under un-irrigated areas. The ability to tolerate effectively by challenging these stresses is a complicated phenomenon stemming out from various plant interactions occurring in specific environments. Abiotic stresses are occurring naturally, and agronomists, breeders and researchers can only think of mitigation strategies for these stresses under varied climatic conditions. They have been able to develop some promising cultivars that are tolerant to various abiotic and biotic stresses as depicted in Table 2.

2.2 Salinity Stress

Salt stress mostly lowers the fresh and dry biomass, shoot and root length, mungbean yield parameters, and seed germination in most crops [14]. It interferes with root elongation and growth, which hinders the uptake and dispersion of nutrients. Increases in the content of sodium chloride (NaCl) result in a considerable reduction in root development. A larger decrease in seed output is seen during the reproductive stage of growth because of the metabolites' diminished partitioning. In mungbean, salinity-induced desiccation, blossom shedding, and pod breaking, together with other pests including yellow mosaic disease and stem and pod borer, resulted in an 80–100% yield loss, especially during the rainy season [15].

2.3 Heat Stress

Temperature extremes, both high (heat stress) and low (cold stress), is detrimental to all the developmental stages of plant which causes a significant loss in output. According to Hanumantha Rao *et al.* [16] and Sharma *et al.* [17], mungbean exhibit variable degrees of sensitivity to high and low temperature stresses. This lowers their potential performance at various developmental stages, including germination, seedling emergence, vegetative phase, flowering, and pod/seed filling phase. The ideal temperature range for mungbean growth and development is 28–30°C, but the plant can continue to generate seed in a range of 33–35°C. According to Sharma *et al.* [17], for every degree that the temperature rises beyond the optimal range, the seed yield decreases by 35–40%.

2.4 Moisture Stress

Mungbean is widely regarded as a drought-tolerant crop since it is planted on marginal terrain and can tolerate low soil moisture levels. It does, however, respond to a drop in soil moisture availability like any other plant by slowing down its development and consequently its productivity. A decline in seed yield by 50-60% was observed when the crop was subjected to moisture stress during flowering stage [18]. Furthermore, the synthesis and partitioning of dry matter has a significant impact on the productivity of plants under drought stress [19,20,21].

2.5 Waterlogging Stress

Waterlogging has a negative impact on root and shoot growth, crop establishment, seedling emergence and growth, and germination [22]. Severe rainfall at the stage of pod ripening causes the seeds to sprout prematurely, resulting in low quality. According to Singh and Singh [23], mungbean is primarily grown in rice-fallow systems and is susceptible to waterlogging. In these types of farming methods, too much rainfall can cause waterlogging, in which the roots are totally covered in water and the shoots are occasionally partially or completely submerged. Since there is little rainfall in the spring, crops cultivated during this time are more vulnerable to water stress. Consequently, growing short-duration cultivars could aid in avoiding terminal moisture stress [24].

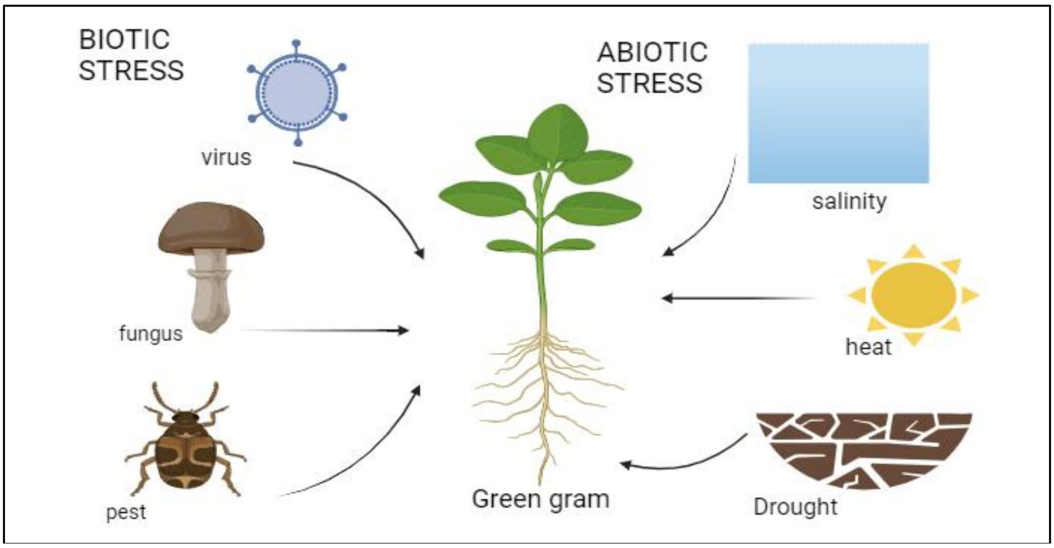

Fig. 1. Various abiotic and biotic stress in green gram

Table 1. Major biotic and abiotic stress in mung bean

Crop	Growth season	Biotic stress	Abiotic stress
Mung bean	Kharif Zaid Rabi	Weeds, mosaic virus, sucking insect-pests Mosaic virus, root, and stem rot Weeds, powdery mildew, rust.	Pre harvesting sprout, terminal drought Preharvest sprouting, heat stress, insect pests Terminal drought
Other Pulses			
Pigeon Pea	Kharif early Medium late Pre rabi	Weeds, Fusarium wilt, blight, pod-borer. Weeds, Fusarium wilt, mosaic, pod-borer Weeds, wilt, leaf blight, pod-fly.	Waterlogging, nutrient stress. Complex Cold, terminal drought, waterlogging. Cold, Terminal drought
Urd bean	Kharif Rabi Zaid	Weeds, mosaic and leaf curl virus, anthracnose Mosaic virus, root, and stem rot Leaf spot	Terminal drought Terminal drought Pre-harvest sprouting, heat stress, drought.
Chickpea	Timely sown Early sown Late sown	Weeds, fusarium wilt, root rot, grey mold pod borer Fusarium wilt, root rot, blight, stunt, pod-borer Weeds, fusarium wilt, pod borer	Low temperature, nutrient stress Terminal drought, salt stress Terminal drought, cold

3. SOURCES OF RESISTANT TO MAJOR ABIOTIC STRESSES IN MUNG BEAN

Researchers have been examining a number of approaches to address these abiotic stresses and ensure sustainable mung bean production. These include varied agronomic practices, breeding for stress-tolerant varieties, and creating bio-fortified mung bean lines with increased stress tolerance through molecular breeding or genetic engineering. Some of the resistance sources have been identified (Table 3) by their efforts towards developing resistant cultivars of mung bean.

Table 2. Promising cultivars for abiotic and biotic stress tolerance in India [20]

Cultivars (Mung bean)	Abiotic stress	Cultivars	Biotic stress
RMG 268	Drought stress	Pusa Vishal, PM 5, HUM16, SML668, RMG492, Pusa 9531, Co 6, GG2	Yellow mosaic
JM 721, TJM3, SML668	Delayed monsoon	HUM16, SML668	Root knot nematode
Narendra Mung, IPM2-3, IPM214, LGG460, LGG410	Heat stress	BM 2002-1	Powdery mildew

Table 3. Major abiotic stress and their source of tolerance

S. No.	Abiotic stresses	Source of tolerance	Country	Reference
1.	Drought	VC 1163 D, VC 2570A,	Taiwan	[25]
2.	Drought	ML 267	India	[26]
3.	Drought	K-851	India	[27]
4.	Drought	TCR 20	India	[28]
5.	Drought	SML-1411, SML-1136	India	[29]
6.	Drought	VC 2917 (seedling stage)	China	[30]
7.	Drought (maintaining cooler canopy traits)	VC-6173-C, IC-325770, ML 2082	India	[31]
8.	Salt	NM 19-19	Pakistan	[32]
9.	Salt	TCR86, PLM380, PLM562, WGG37, IC615, PLM891, IC2056, IC10492, PLM32, K851, and BB92R	India	[33]
10.	Salt	BARI Mung-4	Bangladesh	[34]
11.	Salt	T-44	India	[35]
12.	Salt	EC 693357, 58, 66, 71 and ML 1299	India	[36]

3.1 Biotic Stresses

Damage to plants by other living things, such as weeds, insect pests, disease-causing organisms, nematodes, allelopathic chemicals, etc., results in biotic stress. The two biggest and most significant groups among them, impacting every part of the plant at every stage of crop development, are fungi and viruses Pande [13]. A key obstacle to raising the yield of the mungbean crop is insect pests and diseases. A number of significant diseases can affect mungbean, including bacterial leaf spot, tan spot, dry root rot, anthracnose, powdery mildew, and Cercospora leaf spot. Thrips, aphids, whiteflies, pod borers, bruchids, and stem flies are the main insect pests of mungbean. Breeding for resistance in mungbean plants is an innovative, cost-effective, and environmentally beneficial method of developing plant resistance to diseases and insect pests.

3.2 Weeds

The most pressing issue right now is weeds, which need a lot of scientific study. Unchecked weeds reduce production in several pulse crops by 20–90% [20]. Since mung bean have a sluggish growth tendency, early vegetative development phases are more likely to be heavily infested by weeds. Mung bean is infested by weeds like *Cynodon dactylon, Cyprus rotundus, Amaranthus* spp*, Bedens Pilosa, Physalis minima* etc. These weeds cause about

50-90% yield loss in the crop. In the first three to four weeks, mungbean is comparatively sluggish and this invites more weed in the field. Weeds are a severe concern for mung bean. Additionally, weeds harbor diseases, nematodes, and insect pests that harm the crop.

3.3 Diseases

Diseases caused by viruses, bacteria, and fungi are significant economic issues in Sub-Saharan Africa, South Asia, and Southeast Asia [37,38]. According to Noble *et al.* [39], mungbean yellow mosaic disease (MYMD) is a significant viral disease. Many begomoviruses, which are spread by the whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), are the cause of MYMD [40]. The three main fungal diseases are anthracnose (*Colletotrichum acutatum*), powdery mildew (*Podosphaera fusca*) and Cercospora leaf spot (CLS) (*Cercospora canescens*). An emerging diseases detected in mung bean is root rot (*Macrophomina phaseolina*). MYMD accounts for 85% yield loss in crop [41]. In different parts of India yield loss due to CLS accounts for 97% while powdery mildew causes 40% yield loss [42].

Table 4. Characteristic symptoms of various fungal diseases

Diseases type	**Causal organism**	**Symptoms**
Cercospora leaf spot	*C. cruenta, C.cenescens, C.kikuchii, C.dolichi, C.corocollae*	Small leaf spots (1–5 mm) with brown to greyish centres and reddish border
Powdery mildew	*Erysiphae polygoni*	White powdery coating on leaves, stems and pods
Anthracnose	*Colletotrichum trancatum*	Circular, brown, sunken spots with dark centres and bright red orange margin leaves
Dry root rot	*Macrophomina phaseolina*	Dark brown patch on stem with black dot-like sclerotia and brown pycnidia
Rhizoctonia root rot	*Thanatephorus cucumeris*	Necrotic small circular brown spots, fungal hyphae are seen spreading like spider web on the affected leaves with sclerotia
Alternaria leaf spot	*Alternaria alternata*	Leaf spots with concentric rings leading to ‘shot holes’
Rust	*Uromyces appendiculatus*	Reddish brown pin head uredo pustules surrounded by yellow

Table 5. Characteristic symptoms of various bacterial diseases

Diseases type	**Casual organism**	**Symptoms**
Halo blight	*Pseudomonas syringae*	Water-soaked spots surrounded by a greenish yellow halo
Bacterial leaf spot	*Xanthomonas Campestris*	Brown raised spots on both surfaces which later become necrotic, water-soaked or with translucent border
Tan spot	*Curtobacterium flaccumfaciens*	Papery brown lesions originating on the leaf margins and spreading inwardly
Viral disease		
Mung bean yellow mosaic disease (MYMD)	Mung bean yellow mosaic virus (MYMV)	small yellowish spots appear on green lamina of young leaves which develops into a characteristics bright yellow mosaic or golden yellow mosaic symptom soon

4. CHARACTERISTIC SYMPTOMS OF VARIOUS FUNGAL AND BACTERIAL DISEASES

4.1 Insect-Pests

Mungbean is attacked by insect pests at every stage of the crop cycle, from seeding to storage, severely reducing crop production. While some insect pests cause direct crop harm, others spread illness. Stem flies, thrips, aphids, whiteflies, pod borer complex, pod bugs, and bruchids are among the economically significant insect pests in mungbean [43]. One of the main pests of mungbean is the stem fly, often known as the bean fly (*Ophiomyia phaseoli*, Tryon). The whitefly, *B*. *tabaci*, is a significant pest of mungbean. It causes damage to the crop directly by feeding on phloem sap and excreting honeydew, which develops black sooty mold on the plant, or indirectly by spreading MYMD. Thrips infest the crop in both flowering and seedling stages. However, some resistant genotypes have been successfully developed to combat these biotic stresses such as diseases, insect pests etc. which are highlighted in Table 6.

5. MANAGEMENT APPROACHES FOR BIOTIC AND ABIOTIC STRESSES

To sustain pulse production, low-cost agronomic practices need to be adopted, including crop selection, drought-resistant varieties, healthy seeds, and seed treatment [44,13]. Better crop management practices, comprising nutrient, water, weed, insect-pest, and disease management, are essential. Climate-resilient crop varieties and adaptation strategies can help overcome adverse impact of climate change on yield losses [45]. Some of the management strategies have been discussed below:

5.1 Selection of Suitable Cultivar

In order to maintain continuity in production and adapt to changing climatic conditions, it is imperative to identify and develop biotic and abiotic stress-resistant cultivars. The resistant cultivars to various abiotic and biotic stresses have been displayed in Tables 3 and 6 respectively. Plant response to biotic and abiotic stressors is often cultivar specific [45]. In low-rainfall and terminally drought situations selection of short-duration crops that are early on and suitable to withstand heat stress and drought is a widely employed trait. In order to produce a satisfying yield with high productivity potential under stress conditions, agronomists must prioritize the selection of stress-tolerant cultivars, whose development is under genetic control.

5.2 Agronomic Practices

Crop management practices in India can increase productivity of mung bean by mitigating abiotic and biotic stresses. Tillage is essential for ideal seed germination and growth [46]. Conservation tillage can be opted in moisture deficit areas. Non-monetary inputs like sowing time and method significantly influence crop growth and productivity. Adjusting sowing dates, sowing methods, and spacing have a key role on crop growth, phenological development, insect-pests and weed dynamics and crop productivity. The incidence of Powdery mildew caused by *Erysiphe polygoni* DC. can be reduced by adjusting sowing dates in the crop with resistant varieties keeping wider spacing [13]. Bed planting, ridge and furrow systems, and mulching are beneficial for water-stress management. These practices are especially beneficial in areas with saline irrigation water [47].

5.3 Nutrient Management

The requirement of nutrients is quite low in this crop because of the ability to fix nitrogen. These react well to increased potassium (K), sulfur (S), and phosphorus (P) applications. Effective management of nutrients, particularly nitrogen along with biofertilizers can reduce the amount and duration of moisture stress. The use of micronutrient-rich balanced fertilizers (NPK) improves the plant's ability to absorb water and regulate its water relations in plant tissues that support higher susceptibility to heat stress and drought. Soil- test crop response (STCR) based precision nutrient management practices in crop can enhance crop productivity in India by reducing nutrient and moisture stress, reducing the need for chemical fertilizers [48]. Foliar application of nutrients and anti-transpirants in pulses is recommended due to low productivity, erratic rainfall and prolonged dry spells during flowering and pod-formation stages leading to low productivity. This situation requires foliar application of nutrients along with in-situ moisture-conservation practices for better crop-stand establishment and production [12].

5.4 Integrated Pest Management (IPM)

In addition to applying pesticides at the lowest possible levels, integrated pest management (IPM) employs non-host crop rotation, the adoption of resistant or tolerant cultivars, and other strategies. Furthermore, the removal of some soil-borne pests, such nematodes, and increased soil nutrient availability are additional advantages of conservation agriculture. Validation of crop-protection methodologies and their applicability to specific farming systems and socio-economic situations is crucial for the development of integrated insect-pest management modules. Cultural practices include hot water treatment of seeds at 52° C for 10 min is effective for anthracnose, Similarly, intercropping can be done with pigeon pea, marigold, and castor for insects. Destruction of disease and insect infested plant parts and use of yellow/ sticky traps @ 4–5 traps/acre is also helpful. Biological control includes seed treatment with Trichoderma viridae 1% WP @ 4 g/kg seeds. Chemical control comprises Quinalphos 25% EC 600 ml in 200–400 l/acre, Phenthoate 50% EC 320 ml in 200–400 l/acre [49]. The aforementioned techniques are some of the IPM strategies that can be applied.

6. BREEDING APPROACHES FOR MANAGEMENT OF BIOTIC STRESS

6.1 For Pests

It is crucial to comprehend plant-insect interactions in order to breed for resistance to insect pests. Understanding the biology of the insect pest, the stage of infestation, and the biochemical and molecular aspects of insect-plant interactions are some of the crucial requirements for successfully breeding for insect resistance. For developing pest diseases resistant cultivars along with other target traits mutation can be induced in mung bean by the use of physical and chemical mutagens [50,51]. Mass selection, recurrent selection, and pure line selection are a few methods used in conventional breeding to create cultivars resistant to insects. Insect resistance and other agronomic features are being developed in mungbean using techniques like bulk selection, pedigree breeding, and backcross breeding. Various markers like RAPD, RFLP, SSR, SNP$_S$ are utilized in breeding for pest and disease resistant plants. SNP markers have been used more and more recently to create plants resistant to pests and diseases. They are highly helpful because of their widespread, abundant presence in the genome and ease of availability for genotyping [52].

6.2 For Diseases

The most promising method for developing disease-resistant cultivars is marker-assisted selection, or MAS. The understanding of genotypic variety, the identification of linked markers for the R gene, and the creation of quantitative trait loci (QTL) maps using molecular markers have enhanced the proficiency of breeding programs that confer resistance to MYMD [53]. In mungbean, created a yellow mosaic virus resistance related marker called "VMYR1." QTL-linked markers will be helpful in marker-assisted breeding to create mungbean cultivars resistant to MYMD. By using linked marker-assisted genotyping, plant breeders can repeat genotyping during the growth season if disease incidence is not present. This method will save time and effort during the introgression of MYMD-resistance through molecular breeding. SSR marker-based QTLs linked to resistance to powdery mildew, such as qPMR-1 and qPMR-2, were discovered by [41]. Mungbean line V4718 Two minor QTLs on linkage group 4 and one major QTL on linkage group 9 were identified on mungbean line V4718 [54].

Table 6. Source of tolerance for various biotic stress

Insect pests	Source of tolerance	References
White fly	M92,	[55]
	PDM 91–249, ML 803, ML 839, and PBM 5	[56]
	ML 1265 and ML 1229	[57]
	ML 1774 and ML 1779	[58]
	TMB 36 and RMG 1004	[59]
Thrips	PlMS 2, PIMS 3, CO 3, ML 5, and ML 337	[10]
	NM 92	[55]
Stem fly	V2396, V3495, and V428 I	[60]
Pod borer	JI, LM 11, P526, and Co3	[61]
	ML 337, ML 423, and ML 428	[10]
Maruca pod borer	MGG 364, MGG 365, and MGG 363	[62]
Weevil	KM-12-5 and P-S-16	[63]

Table 7. Source of tolerance for various diseases

Name of diseases	Source of tolerance	References
Mung bean yellow mosaic disease	IW 3390, EC 398897, TM-11-07, TM-11-34, PDM-139, IPM-02-03, IPM-02-14, Pusa-0672, Pusa-0871, CO-7 and MH-521	[64]
Powdery mildew	NCM 255-2, NCM 257-6, ML-267, NCM 251-1, NCM 259-2, NCM 251-13, NCM 257-2, NM-92, NCM 251-12, VC-3960-A88, NCM 257-10, NCM-209, Mung-6 C1/94-4-19, VC	[65]
Leaf crinkle	40504, NCM 257-5, 40457, NCM 251-4, 6368-64-72 (resistant) HR: NCM 252-10 and 40536 (highly resistant)	[66]
Cercospora leaf spot	D 215, HPM 1, Madana 1, M 58, ML 12, T44, V 2182 and V 2294	[67]

7. BREEDING APPROACHES FOR MANAGEMENT OF ABIOTIC STRESS

Several successful attempts have been made at the plant level in mungbean to screen and identify tolerant types from physiological, biochemical, and molecular perspectives for high temperature (heat stress), salinity, waterlogging, and water stress [68,16,69,70,21]. The breeding lines that were chosen and recognized for the aforementioned stress would serve as a donor source for crop improvement. The various sources of tolerance have been mentioned in Table 3. In order to protect them from drought stress and terminal heat, Pratap et al., [11] recommended the development of short duration cultivars for spring/summer growing. Summer-season cultivars include those having a crop cycle of 60–65 days, a determinate growth habit, a high harvest index, less sensitivity to photoperiod changes, rapid initial development, longer pods holding more than 10 seeds each, and large seeds. Considering this, some mungbean lines with early maturities have been chosen and made available as commercial cultivars.

8. FUTURE PROSPECTS

An essential component for maintaining the high-yield, sustainable production of mung beans (*Vigna radiata*), a significant legume crop that is farmed all over the world, is the management of biotic and abiotic stressors. In order to effectively manage abiotic and biotic stress in mung bean cultivation, a multifaceted approach is needed, one that makes use of advanced breeding techniques like genetic engineering and marker-assisted selection to create stress-tolerant varieties. Exploring genetic diversity, adoption of precision agriculture technologies [71,72], implementation of sustainable crop management practices like integrated pest management and conservation agriculture, utilization of microbial inoculants such as plant growth-promoting rhizobacteria and arbuscular mycorrhizal fungi, exploration of nanotechnology-based formulations for targeted input delivery, integration of climate-smart agriculture practices to adapt to the effects of climate change and utilization of digital agriculture tools like decision support systems and crop monitoring for early detection and effective management of various stresses [73-75]. The future of biotic and abiotic stress management in mung beans lies in the above-mentioned approach [76,77].

9. CONCLUSION

This review has offered a thorough examination of the ways in which several biotic and abiotic stress variables affect the growth, development, and productivity of green grams. Different abiotic stresses like heat, salinity, drought are damaging the crop to a greater extent declining the yield and productivity. Insect pests such as aphids, thrips, and lepidopteran larvae are major risks to plants when it comes to biotic stressors since they can cause defoliation, sap-sucking, and the transmission of viral infections. Inappropriate management of these insects can severely reduce productivity. Green Gram is also frequently infected by bacterial and fungal diseases, which can lead to rots, wilts, and blights that impair physiological processes. When several biotic and abiotic pressures coexist at the same time, the harmful effects might compound and become even more severe. Going forward, stress levels for green gram production systems will probably grow because of the continued problems posed by climate change, such as higher heat waves, droughts, and disease pressures. The development of green gram cultivars with increased stress resilience is a key to address the issue which however will depend on harnessing genetic resources through breeding and biotechnological methods, molecular approaches. To safeguard green gram yields under the various unfavorable environmental conditions, it will be essential to supplement this with enhanced agronomic management tactics that reduce abiotic stresses along with integrated pest/disease control strategies.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kumari S, Kumar R, Chouhan S, Chaudhary PL. Influence of various organic amendments on growth and yield attributes of mung bean (*Vigna radiata* L.). International Journal of Plant & Soil Science. 2023; 35(12):124-30.
2. Sharma A, Rathod PS, Chavan M. Response of pigeonpea (Cajanus cajan) to drought management practices under rainfed conditions. Karnataka Journal of Agricultural Sciences. 2010;23(5):693-700.
3. Arunima AS, Manju RV, Viji MM. Roy S, Sarada S, Beena R. Role of Nutrients and Biofertilizers for Improved Tolerance of Tomato under Elevated Co2 Induced High Temperature Stress”. Journal of Experimental Agriculture International. 2023;45(12):9-15.
Available:https://doi.org/10.9734/jeai/2023/v45i122260.
4. Sisodiya RR, Vasave JB, Jaimin R. Naik. “Crop Residues Management: A Viable Tool for Sustainable Agriculture”. International Journal of Plant & Soil Science. 2023;35(19):1750-54.
Available:https://doi.org/10.9734/ijpss/2023/v35i193724.
5. Cushman JC, Bohnert HJ. Genomic approaches to plant stress tolerance. Current opinion in plant biology. 2000;3 (2):117-24.
6. Hilder VA, Boulter D. Genetic engineering of crop plants for insect resistance–a critical review. Crop protection. 1999;18 (3):177-91.
7. Raina SK, Govindasamy V, Kumar M, Singh AK, Rane J, Minhas PS. Genetic variation in physiological responses of mungbeans (*Vigna radiata* (L.) Wilczek) to drought. Acta Physiologiae Plantarum. 2016;38:1-2.
8. Mohan S, Sheeba A, Murugan E, Ibrahim SM. Screening of mungbean germplasm for resistance to mungbean yellow mosaic virus under natural condition. Indian Journal of Science and Technology. 2014; 891-6.
9. Naher N, Alam AK. Germination, growth and nodulation of mungbean (*Vigna radiata* L.) as affected by sodium chloride. Int. J. Sustain. Crop Prod. 2010;5(2):8-11.
10. Chhabra KS. Bean Aphid, Aphis Craccivora Koch (Homoptera: Aphididae) in Grain Legume Crops: A Global Overhaul. Journal of Aphidology. 2005;19: 17-24.
11. Sahoo L, Sugla T, Jaiwal PK. In vitro regeneration and genetic transformation of cowpea, mungbean, urdbean and azuki bean. Applied genetics of leguminosae biotechnology. 2003:89-120.
12. Chouhan S, Kumari S, Kumar R, Chaudhary PL. Climate resilient water management for sustainable agriculture. Int. J. Environ. Clim. Change. 2023;13(7): 411-26.
13. Rathore M, Yellanki Pravalika RK, Tutlani A, Aggarwal N. Enhancing seed quality and insect management in wheat (*Triticum aestivum* L.) through optimization of storage treatments with natural and chemical compounds. Plant Archives. 2024;24(1):26-36.
14. Dubey SC, Singh B, Tripathi A. Integrated management of wet root rot, yellow mosaic, and leaf crinkle diseases of urdbean by seed treatment and foliar spray of insecticide, fungicide, and biocontrol agent. Crop Protection. 2018;112:269-73.
15. Sharma L, Priya M, Bindumadhava H, Nair RM, Nayyar H. Influence of high temperature stress on growth, phenology

and yield performance of mungbean [*Vigna radiata* (L.) Wilczek] under managed growth conditions. Scientia Horticulturae. 2016;213:379-91.

16. Bhandari K, Sharma KD, Hanumantha Rao B, Siddique KH, Gaur P, Agrawal SK, Nair RM, Nayyar H. Temperature sensitivity of food legumes: a physiological insight. Acta Physiologiae Plantarum. 2017;39:1-22.
17. Swaminathan R, Singh K, Nepalia V. Insect-pests of green gram *Vigna radiata* (L.) Wilczek and their management. Agricultural science. 2012;10:197-222.
18. Bains K, Yang RY, Shanmugasundaram S. High-iron mungbean recipes for North India. AVRDC-World Vege table Center; 2003.
19. Kasettranan W, Somta P, Srinives P. Mapping of quantitative trait loci controlling powdery mildew resistance in mungbean (*Vigna radiata* (L.) Wilczek). Journal of crop science and biotechnology. 2010; 13:155-61.
20. Tutlani A, Kumar R, Kumari S, Chouhan S. Correlation and path analysis for yield and its phenological, physiological, morphological and biochemical traits under salinity stress in chickpea (*Cicer arietinum* L.). International Journal of Bio-resource and Stress Management. 2023;14:878-90.
21. Paudel P, Pandey MK, Subedi M, Paudel P, Kumar R. Genomic approaches for improving drought tolerance in wheat (*Triticum aestivum* L.): A Comprehensive Review. Plant Archives. 2024;24(1):1289-300.
22. Kaur R, Kaur J, Bains TS. Screening of mungbean genotypes for drought tolerance using different water potential levels. J Adv Agric Technol. 2017;4(2).
23. Toker C, Mutlu N. 16 Breeding for Abiotic Stresses. Biology and breeding of food legumes. 2011:241.
24. Sehgal A, Sita K, Siddique KH, Kumar R, Bhogireddy S, Varshney RK, HanumanthaRao B, Nair RM, Prasad PV, Nayyar H. Drought or/and heat-stress effects on seed filling in food crops: impacts on functional biochemistry, seed yields, and nutritional quality. Frontiers in plant science. 2018;9:1705.
25. Bana RS, Pooniya V, Choudhary AK, Rana KS. Agronomic interventions for sustainability of major cropping systems of India. Technical Bulletin (ICN: 137/2014), Indian Agricultural Research Institute, New Delhi. 2014;34.
26. Dutta P, Bandopadhyay P, Bera AK. Identification of leaf based physiological markers for drought susceptibility during early seedling development of mungbean. American Journal of Plant Sciences. 2016;7(14):1921-36.
27. Ahmed S. Effect of soil salinity on the yield and yield components of mungbean. Pak. J. Bot. 2009;41(1):263-8.
28. Wang LX, Elbaidouri M, Abernathy B, Chen HL, Wang SH, Lee SH, Jackson SA, Cheng XZ. Distribution and analysis of SSR in mung bean (*Vigna radiata* L.) genome based on an SSR-enriched library. Molecular breeding. 2015;35:1-0.
29. Das TK, Choudhary AK, Sepat S, Vyas AK, Das A, Bana RS, Pooniya V. Conservation agriculture: A sustainable alternative to enhance agricultural productivity and resourcesuse-efficiency. Technical Extension Folder, IARI, New Delhi; 2014.
30. Shakeel SA, Mansoor S. Salicylic acid prevents the damaging action of salt in mungbean [(*Vigna radiata* L.) Wilczek] seedlings. Pak. J. Bot. 2012;44(2):559-62.
31. Sehrawat N, Yadav M, Bhat KV, Sairam RK, Jaiwal PK. Effect of salinity stress on mungbean [*Vigna radiata* (L.) Wilczek] during consecutive summer and spring seasons. Journal of Agricultural Sciences, Belgrade. 2015;60(1):23-32.
32. Sudha M, Karthikeyan A, Anusuya P, Ganesh NM, Pandiyan M, Senthil N, Raveendran M, Nagarajan P, Angappan K. Inheritance of resistance to mungbean yellow mosaic virus (MYMV) in inter and intra specific crosses of mungbean (*Vigna radiata*). American Journal of Plant Sciences. 2013;4(10):1924.
33. Singh DP, Singh BB. Breeding for tolerance to abiotic stresses in mungbean. Journal of food legumes. 2011;24(2):83-90.
34. Noble TJ, Young AJ, Douglas CA, Williams B, Mundree S. Diagnosis and management of halo blight in Australian mungbeans: a review. Crop and Pasture Science. 2019; 70(3):195-203.
35. Mbeyagala KE, Amayo R, Obuo JP, Pandey AK, War AR, Nair RM. A manual for mungbean (greengram) production in Uganda. National Agricultural Research Organization (NARO). 2017;32.
36. Maheswari M, Sarkar B, Vanaja M, Rao MS, Rao CS, Venkateswarlu B, Sikka AK. Climate resilient crop varieties for

sustainable food production under aberrant weather conditions.

37. Manasa R, Bindumadhava H, Nair RM, Prasad TG, Shankar AG. Screening mungbean (*Vigna radiata* L.) lines for salinity tolerance using salinity induction response technique at seedling and physiological growth assay at whole plant level; 2017.
38. Pooniya V, Choudhary AK, Dass A, Bana RS, Rana KS, Rana DS, Tyagi VK, Puniya MM. Improved crop management practices for sustainable pulse production: An Indian perspective. The Indian Journal of Agricultural Sciences. 2015;85(6):747-458.
39. Pandey AK, Burlakoti RR, Kenyon L, Nair RM. Perspectives and challenges for sustainable management of fungal diseases of mungbean [*Vigna radiata* (L.) R. Wilczek var. radiata]: a review. Frontiers in Environmental Science. 2018;6:53.
40. Pande S. Integrated foliar diseases management of legumes.
41. Chandrashekar K, Gupta O, Yelshetty S, Sharma OP, Bhagat S, Chattopadhyay C, Sehgal M, Kumari A, Amaresan N, Sushil SN, Sinha AK. Integrated pest management for chickpea. National Centre for Integrated Pest Management, New Delhi, India. 2014:43.
42. El-Nakhlawy FS, Ismail SM, Basahi JM. Optimizing mungbean productivity and irrigation water use efficiency through the use of low water-consumption during plant growth stages. Legume Research-An International Journal. 2018;41(1):108-13.
43. Swathi L, Reddy DM, Sudhakar P, Vineela V. Screening of Mungbean (*Vigna radiata* L. Wilczek) genotypes against water stress mediated through polyethylene glycol. International Journal of Current Microbiology and Applied Sciences. 2017; 6(10):2524-31.
44. Pravalika Y, Aggarwal N, Kumar R, Tutlani A, Parveen S, Rathore M. Genotypic Variability, Correlation and Path Coefficient Analysis for Elite Genotypes of Chickpea (*Cicer arietinum* L.). International Journal of Bio-resource and Stress Management. 2024;15(Apr, 4):01-10.
45. Khajudparn P, Wongkaew S, Thipyapong P. Mungbean powdery mildew resistance. Identification of genes for resistance to powdery mildew in mungbean.
46. Lal SS. A review of insect pests of mungbean and their control in India. International Journal of Pest Management. 1985;31(2):105-14.
47. Iqbal J, Yousaf U, Zia S, Asgher A, Afzal R, Ali M, Sheikh AU, Sher A. Pulses Diseases “Important limiting factor in yield”and their Managements. Asian Journal of Research in Crop Science. 2019;3(2):1-21.
48. Wongpiyasatid A, Chotechuen S, Hormchan P, Ngampongsai S, Promcham W. Induced mutations in mungbean breeding: regional yield trial of mungbean mutant lines. Agriculture and Natural Resources. 2000;34(4):443-9.
49. Yadav GS, Dahiya B. Screening of some mung bean genotypes against major insect-pests and yellow mosaic virus. Annals of Agri Bio Research. 2000;5(1):71-3.
50. Manas*a R, Bindumadhava H, Nair RM, Prasad TG, Shankar AG. Screening mungbean (*Vigna radiata L.) lines for salinity tolerance using salinity induction response technique at seedling and physiological growth assay at whole plant level; 2017.
51. Sehrawat N, Yadav M, Bhat KV, Sairam RK, Jaiwal PK. Effect of salinity stress on mungbean [*Vigna radiata* (L.) Wilczek] during consecutive summer and spring seasons. Journal of Agricultural Sciences, Belgrade. 2015;60(1):23-32.
52. Khattak GS, Ashraf M, Khan MS. Assessment of genetic variation for yield and yield components in mungbean (*Vigna radiata* (L.) Wilczek) using generation mean analysis. Pakistan journal of Botany. 2004;36(3):583-8.
53. Weinberger K. The impact of iron bioavailability-enhanced diets on health and nutrition of school children: evidence from a mungbean feeding trial in Tamil Nadu. Proceedings, Why has impact assessment research not made more of a difference. 2002:4-7.
54. Cheema S, Durrani AB, Pasha AT, Javed F. Green human resource practices: Implementations and hurdles of SMEs in Pakistan. Journal of Business Studies Quarterly. 2015;7(2):231.
55. HanumanthaRao B, Nair RM, Nayyar H. Salinity and high temperature tolerance in mungbean [*Vigna radiata* (L.) Wilczek] from a physiological perspective. Frontiers in Plant Science. 2016;7:186318.
56. Misra N, Gupta AK. Effect of salinity and different nitrogen sources on the activity of

antioxidant enzymes and indole alkaloid content in Catharanthus roseus seedlings. Journal of plant physiology. 2006;163 (1): 11-8.

57. Karthikeyan A, Shobhana VG, Sudha M, Raveendran M, Senthil N, Pandiyan M, Nagarajan P. Mungbean yellow mosaic virus (MYMV): a threat to green gram (*Vigna radiata*) production in Asia. International journal of pest management. 2014;60(4):314-24.
58. Singh SK, Singh PS. Screening of mungbean (*Vigna radiata*) genotypes against major insects. Current Advances in Agricultural Sciences (An International Journal). 2014;6(1):85-7.
59. Vijayalakshmi P, Amirthaveni S, Devadas RP, Weinberger K, Tsou SC, Shanmugasundaram S. Enhanced bioavailability of iron from mungbeans and its effects on health of schoolchildren. AVRDC-WorldVegetableCenter; 2003.
60. Tripathy SK, Mohanty P, Jena M, Dash S, Lenka D, Mishra D, Nayak PK, Swain D, Ranjan R, Pradhan K, Senapati N. Identification of seed storage protein markers for drought tolerance in mungbean. Research in Biotechnology. 2016;7.
61. Kaur R, Bains TS, Bindumadhava H, Nayyar H. Responses of mungbean (*Vigna radiata* L.) genotypes to heat stress: effects on reproductive biology, leaf function and yield traits. Scientia Horticulturae. 2015;197:527-41.
62. Talekar NS, Lin CP. Characterization of Callosobruchus chinensis (Coleoptera: Bruchidae) resistance in mungbean. Journal of economic entomology. 1992;85 (4):1150-3.
63. Watanasit A, Ngampongsai S, Thanomsub W. The use of induced mutations for mungbean improvement. Report of an FAO/IAEA Seminar on Mutation Techniques and Molecular Genetics for Tropical and Subtropical Plant Improvement in Asia and the Pacific Region. October 11-15, 1999. The Philippines. 2001:11-2.
64. Nair RM, Götz M, Winter S, Giri RR, Boddepalli VN, Sirari A, Bains TS, Taggar GK, Dikshit HK, Aski M, Boopathi M. Identification of mungbean lines with tolerance or resistance to yellow mosaic in fields in India where different begomovirus species and different Bemisia tabaci cryptic species predominate. European journal of plant pathology. 2017;149:349-65.
65. Brumfield RT, Beerli P, Nickerson DA, Edwards SV. The utility of single nucleotide polymorphisms in inferences of population history. Trends in Ecology & Evolution. 2003;18(5):249-56.
66. Gupta J, Singh UN, Akram M, Mishra RK. Potential of biological control agents for the management of soil-borne pathogens in pulse crops. Journal of Food Legumes. 2021;34(3):149-65.
67. Choragudi SR, Rao GR, Chalam MS, Kumar PA, Rao VS. Efficacy of leaf extracts and newer insecticides against Maruca vitrata in greengram. Indian journal of plant protection. 2015;43(1):12-6.
68. Chankaew S, Somta P, Isemura T, Tomooka N, Kaga A, Vaughan DA, Srinives P. Quantitative trait locus mapping reveals conservation of major and minor loci for powdery mildew resistance in four sources of resistance in mungbean [*Vigna radiata* (L.) Wilczek]. Molecular breeding. 2013;32:121-30.
69. Soumia PS, Srivastava C, Dikshit HK, Guru Pirasanna Pandi G. Screening for resistance against pulse beetle, Callosobruchus analis (F.) in greengram (Vigna radiata (L.) Wilczek) accessions. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences. 2017;87:551-8.
70. Krishnamurthy L, Kashiwagi J, Gaur PM, Upadhyaya HD, Vadez V. Sources of tolerance to terminal drought in the chickpea (*Cicer arietinum* L.) minicore germplasm. Field Crops Research. 2010; 119(2-3):322-30.
71. Gulzar I, Kumar S, Shikari AB, Dar ZA, Rashid Z, Lone AA, Wani FJ, Tutlani A, Kumar R. Exploring correlations, diversity and principal component analysis of agromorphological and seed quality traits in rajmash (*Phaseolus vulgaris* L.). Plant Archives. 2024;24(1):1547-56.
72. Gulzar I, Kumar S, Shikari AB, Dar ZA, Rashid Z, Lone AA, et al. Assessment of DUS Traits in Rajmash (*Phaseolus vulgaris* L.) Genotypes: A Comprehensive Study on Genetic Diversity and Morphological Characteristics. International Journal of Bio-resource and Stress Management. 2024;15:01-12.
73. Kooner BS, Cheema HK. Screening of black gram germplasm for resistance to whitefly, Bemisia tabaci (Gennadius) and

MYMV. Journal of Insect Science-Ludhiana. 2007;20(1):124.

74. Basak J, Kundagrami S, Ghose TK, Pal A. Development of Yellow Mosaic Virus (YMV) resistance linked DNA marker in Vigna mungo from populations segregating for YMV-reaction. Molecular Breeding. 2005;14:375-83.
75. Pratap A, Sen Gupta D, Singh BB, Kumar S. Development of super early genotypes in greengram [*Vigna radiata* (L.) Wilczek]. Legume Research: An International Journal. 2013;36(2).
76. Suri VK, Choudhary AK. Effect of Vesicular Arbuscular–Mycorrhizal Fungi and Phosphorus Application through Soil-Test Crop Response Precision Model on Crop Productivity, Nutrient Dynamics, and Soil Fertility in Soybean–Wheat–Soybean Crop Sequence in an Acidic Alfisol. Communications in soil science and plant analysis. 2013;44(13): 2032-41.
77. Fernandez GC, Shanmugasundaram S. The AVRDC mungbean improvement program: the past, present and future. InMungbean. Proceedings of the Second International Symposium held at Bangkok, Thailand, 16-20 November. 1987;1988:58-70.

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