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# Climate Smart Dolichos Bean Breeding: Strategies for Enhancing Productivity Under Abiotic Stress Conditions

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**Abstract: -**

*Dolichos bean (Lablab purpureus L.) is a multipurpose vegetable legume valued for its nutritious pods, seeds, fodder, and soil enriching properties. The crop possesses remarkable adaptability to diverse agro climatic conditions and is increasingly recognized as a climate resilient species. However, the growing frequency of drought, heat waves, erratic rainfall, and soil salinity associated with climate change poses serious challenges to its productivity. Developing climate smart dolichos bean cultivars capable of maintaining stable yields under adverse environmental conditions has therefore become a major breeding objective. Conventional breeding methods have successfully exploited genetic variability for yield improvement, but their efficiency is often limited by the complex inheritance of stress tolerance traits. Recent advances in genomics, molecular markers, high throughput phenotyping, and genome editing provide new opportunities to accelerate the development of stress resilient cultivars. The integration of genetic diversity, physiological traits, and modern breeding tools can enhance adaptation to drought, heat, and salinity stresses while sustaining productivity. This review discusses the impact of major abiotic stresses on dolichos bean, available genetic resources, conventional and genomics assisted breeding approaches, and emerging technologies for climate smart crop improvement. The adoption of integrated breeding strategies will play a crucial role in ensuring sustainable production of dolichos bean under changing climatic conditions.*

***Keywords:*** *Dolichos bean, Lablab purpureus, climate smart breeding, abiotic stress, drought tolerance, heat tolerance, salinity stress, genomic selection, climate resilience, yield stability etc.*

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## 1. Introduction:

Climate change has emerged as one of the most significant challenges to global agriculture, affecting crop productivity through increased temperatures, irregular rainfall patterns, prolonged droughts, and soil degradation. Vegetable legumes are particularly vulnerable because reproductive growth stages are highly sensitive to environmental stresses. Among these crops, dolichos bean (Lablab purpureus L.) has gained attention as a climate resilient legume due to its adaptability to drought-prone and marginal environments (Basu *et al*.,2026).

Dolichos bean is cultivated extensively across Asia and Africa for its tender pods, dry seeds, forage, and green manure value. The crop contains approximately 20–25% protein and serves as an important source of nutrition for rural communities. Despite its resilience, severe drought, heat stress, and salinity can significantly reduce flowering, pod setting, seed development, and overall yield. Therefore, developing climate-smart varieties capable of sustaining productivity under abiotic stress conditions has become a priority for breeders.

Recent advances in plant breeding, genomics, and phenomics have created new opportunities to improve stress tolerance in underutilized legumes such as dolichos bean. Climate smart breeding combines conventional breeding with molecular and genomic tools to accelerate the development of superior cultivars adapted to future climatic conditions (Basu *et al*.,2026).

## 2. Dolichos Bean as a Climate Resilient Vegetable Legume

Dolichos bean is considered one of the most versatile legume crops because of its ability to survive under limited water availability and poor soil fertility conditions. The crop exhibits deep rooting characteristics, efficient water utilization, and considerable adaptability to high temperature environments. These traits enable dolichos bean to maintain growth and productivity where many vegetable crops fail.

In addition to its agronomic advantages, dolichos bean contributes to sustainable agriculture through biological nitrogen fixation, which improves soil fertility and reduces dependence on synthetic fertilizers. These characteristics make the crop particularly suitable for climate smart farming systems.

## 3. Major Abiotic Stresses Affecting Dolichos Bean Productivity

### 3.1 Drought Stress

Drought is the most important environmental constraint limiting dolichos bean production. Water deficit reduces seed germination, plant growth, photosynthetic activity, flowering, and pod development.

Drought stress during reproductive stages often causes flower drop and poor pod setting, leading to substantial yield reductions (Noor *et al*.,2024).

Plants respond to drought through osmotic adjustment, stomatal regulation, antioxidant activity, and root system modifications. Breeding programmes therefore focus on identifying genotypes with superior water use efficiency and drought adaptive traits (Jha *et al*.,2024).

**3.2 Heat Stress**

Global warming has increased the occurrence of high temperature stress in agricultural regions. Elevated temperature accelerate crop development, shorten reproductive phases, and negatively affect pollen viability and fertilization.

Heat stress during flowering is particularly damaging because it reduces pod formation and seed set. Developing heat tolerant cultivars capable of maintaining reproductive success under high temperature is therefore essential for future productivity (Noor *et al*.,2024).

**3.3 Salinity Stress**

Soil salinity is becoming a major concern in irrigated and coastal agricultural areas. Excessive salt accumulation inter fere with water uptake, nutrient absorption, and cellular metabolism.

Salinity stress induces ionic toxicity and oxidative damage, reducing plant growth and yield. Identification of salt-tolerant genotypes and incorporation of tolerance genes into breeding programmes represent important strategies for sustaining production in affected regions (Jha *et al*.,2024).

**4. Genetic Resources for Climate-Smart Breeding**

Genetic diversity forms the foundation of crop improvement programmes. The availability of diverse germplasm allows breeders to identify useful genes associated with stress tolerance, yield stability, and adaptation.

Studies on dolichos bean germplasm have revealed substantial variability for flowering behaviour, pod characteristics, plant architecture, and yield related traits. Indigenous landraces and wild relatives often possess adaptive traits that can be exploited in breeding programmes. The conservation and characterization of these genetic resources are therefore essential for future climate-smart breeding efforts (Pootakham et al.,2024).

**5. Conventional Breeding Approaches for Abiotic Stress Tolerance**

Conventional breeding remains an effective approach for developing stress tolerant cultivars. Selection from diverse populations, hybridization among contrasting parents, pedigree breeding, and recurrent selection have been widely employed.

Breeders typically focus on traits such as:

- Early flowering and maturity
- Deep root systems
- Water-use efficiency
- Pod retention under stress
- Stable yield performance across environments

The identification of superior parents possessing complementary traits is essential for developing resilient cultivars adapted to climate variability (Singh).

## 6. Genomics Assisted Breeding for Climate Resilience

Recent advances in genomic technologies have significantly improved the efficiency of breeding programmes.

### 6.1 Molecular Markers

DNA markers such as SSRs and SNPs facilitate the identification of genomic regions associated with stress tolerance. Marker assisted selection enables breeders to select desirable genotypes at early stages without extensive field screening (Venkatesha *et al.*,2025).

### 6.2 Genomic Selection

Genomic selection uses genome wide marker information to predict the breeding value of individuals. This approach is particularly useful for complex traits such as drought tolerance and yield stability that are controlled by many genes.

### 6.3 Genome Sequencing and Gene Discovery

The availability of chromosome scale genome assemblies for lablab has accelerated the identification of candidate genes associated with drought adaptation, heat tolerance, and other stress responsive mechanisms. These genomic resources provide valuable tools for precision breeding (Pootakham et al.,2024).

## 7. Physiological Traits Associated with Abiotic Stress Tolerance

Several physiological traits contribute to stress adaptation in dolichos bean, including:

- Relative water content
- Chlorophyll stability
- Stomatal conductance
- Root length and root biomass
- Osmotic adjustment
- Antioxidant enzyme activity

Selection based on these traits can improve the efficiency of breeding programmes aimed at developing climate resilient cultivars.

## 8. Emerging Technologies in Climate Smart Breeding

### High Throughput Phenotyping

Advanced imaging systems, drones, and sensor technologies enable rapid and precise evaluation of stress responses in large breeding populations.

**Genome Editing**

CRISPR Cas technology provides opportunities for targeted modification of genes controlling stress tolerance and yield related traits.

**Artificial Intelligence and Machine Learning**

AI assisted breeding can improve prediction accuracy, identify superior genotypes, and accelerate selection decisions in breeding programmes.

## 9. Future Prospects

Future research should focus on integrating conventional breeding, genomic selection, phenomics, and genome editing to accelerate genetic gain. Multi environment testing and the utilization of diverse germplasm resources will be essential for developing cultivars capable of maintaining productivity under changing climatic conditions.

Greater investment in orphan crop research, including dolichos bean, can unlock its potential as a climate smart vegetable legume for sustainable agriculture and food security.

## 10. Conclusion

Dolichos bean possesses immense potential as a climate resilient vegetable crop due to its adaptability, nutritional value, and ability to perform under marginal conditions. However, increasing abiotic stresses associated with climate change threaten its productivity. Climate smart breeding approaches that combine genetic diversity, conventional breeding, genomic tools, and emerging biotechnologies offer promising solutions for enhancing stress tolerance and yield stability. The development of drought, heat, and salinity tolerant cultivars will contribute significantly to sustainable vegetable production and future food security.

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