

Breeding for Disease Resistance in Pearl Millet

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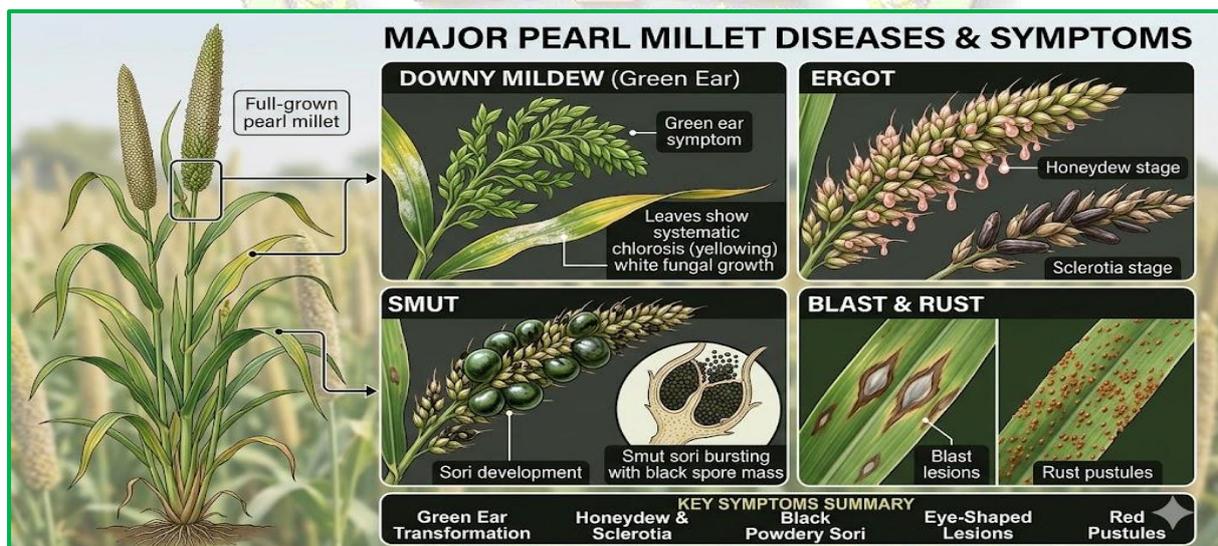
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Pearl millet is a multipurpose cereal crop, belongs to the family *Poaceae* (*graminae*) and sub family *panicoideae*. It is a cross-pollinated diploid ($2n=2\times=14$) species. It is commonly known as bulrush millet, cattail millet, spiked millet or candle millet. It is the most important rainfed cereal crop of India, currently occupying approximately **7.0 million hectares** and yielding **11.63 million tonnes** annually (Chauhan *et al.*, 2025). India remains the world's top pearl millet producer, with **Rajasthan** maintaining the highest production rate and accounting for nearly **45%** of the national acreage. It is gazetted as "Nutricereal" and "Nutritional powerhouse" because of its immense nutritional value. It is a C_4 plant, with high photosynthetic efficiency. Pearl millet is attacked by a large number of diseases caused by fungal, bacterial, viral and nematode pathogens. However, diseases that are considered economically important are only few including downy mildew, blast, rust, ergot and smut. Among these, downy mildew is the most destructive and widespread in India.

Diseases of pearl millet

Major Diseases	Minor Diseases
<ul style="list-style-type: none"> Downy Mildew (<i>Sclerospora graminicola</i>) Ergot (<i>Claviceps fusiformis</i>) Smut (<i>Tolyposporium penicillariae</i>) Rust (<i>Puccinia penniseti</i>) 	<ul style="list-style-type: none"> Blast (<i>Pyricularia setariae</i>) Grain mould (Fungal complex) Zonate leaf spot (<i>Gloeocercospora sp.</i>) Banded leaf spot (<i>Rhizoctonia spp.</i>)



What is disease resistance?

Plant disease resistance is the ability of a plant to withstand or prevent pathogen attack, utilizing both pre-formed physical barriers and active immune responses.

The development of fungal diseases occurs in four stages



Mechanism of Disease Resistance

1. **Escape:** Certain varieties of crop plants which undergo development and maturation, may complete their life cycle before maximal infection occurs.
2. **Tolerance:** Inherent or acquired capacity to endure disease and to give satisfactory returns,
3. **Resistance:** Resistance is relative term and measured by using susceptible cultivars of the same species as checks, which denotes less disease development in the genotype than that in the susceptible variety.
4. **Immune:** Means 100% freedom from infection, Pathogen cannot establish parasitic relationship with the host even under most favourable condition.

Types of disease resistance

1. Vertical (Specific) resistance	2. Horizontal (General) resistance
Specific resistance of host to the particular race of a pathogen governed by mono or oligogenes.	The resistance of a host to most of the prevailing races of pathogen is called horizontal resistance (non-specific resistance or minor gene resistance) and governed by polygenes, and rarely by oligogenes.

Why resistance breeding?

- Less effective control by chemicals.
- Residues of pesticides entering food chain are the limiting factors for chemical control of insect-pests.
- To prevent yield losses.
- Cost effective.
- Easily adoptable.
- Eco-friendly.

Strategy of Resistance Breeding

- Effective screening method
- Availability of diverse germplasm
- Confirmed sources of resistance
- Knowledge of genetics of resistance
- Information on variability in pathogen, its biology and epidemiology
- Conduction of hybridization programs with effective utilization of resistance

Screening methods

1. Field screening
2. Greenhouse screening

Both field and greenhouse screening techniques have been developed at ICRISAT (Williams *et al.* 1981; Singh *et al.* 1993; Singh *et al.* 1997) that are being extensively used worldwide. The greenhouse technique has been further refined to obtain more precise results.

Breeding methods

Conventional breeding methods: Selection, Backcross, Pedigree method, Recurrent selection, Mutation breeding, Heterosis breeding

Non-conventional breeding methods: Marker assisted selection, Genetic transformation

Case studies

Pawar *et al.*, (2016) studied the inheritance of blast resistance using two resistant (ICMB 06444 and DHLB 10B) and two susceptible maintainer lines (ICMB 95444 and ICMB 89111) were selected and three crosses were made *viz.*, ICMB 95444 × ICMB 06444 (susceptible × resistant), DHLB 10B × ICMB 89111 (resistant × susceptible) and DHLB 10B × ICMB 06444 (resistant × resistant) and generations *viz.*, P₁, P₂, F₁, F₂, B₁ and B₂ of each cross were used to study the inheritance of blast resistance in pearl millet. The disease reaction of the F₁s, and the segregation patterns of resistance in the F₂s and backcross generations, the goodness of fit to 3R:1S segregation ratio in the two F₂s (of C-I and C-II) and 1R:1S ratio in their two backcross populations under both greenhouse and field conditions lead to that foliar blast resistance in the pearl millet lines is controlled by a single dominant gene.

Raj *et al.*, (2018) studied the inheritance of DM resistance using F₁, F₂, BC₁P₁ (Susceptible parent × F₁) and BC₁P₂ (Resistant parent × F₁) generations obtained from the cross of three DM resistant pearl millet lines (834B, IP 18294 and IP 18298) and one susceptible line (81B). Segregation pattern revealed monogenic resistance in lines 834B and IP 18294 and digenic resistance in line IP 18298. Tests for allelism inferred the presence of two different genes governing resistance in lines 834B and IP 18294 whereas one dominant gene for DM resistance in IP 18298 was found allelic to the gene in line 834B and second dominant gene in IP 18298 was found allelic to the gene in line IP 18294.

Taunk *et al.*, (2018) used MAS for developing improved hybrid versions of HHB 197 hybrid (an elite pearl millet hybrid) by transferring QTLs for DMR to its male parent HBL 11 from ICMP 451 by backcrossing. Breeding programme was initiated by crossing HBL11 with ICMP 451. BC₃F₁ lines were generated after three rounds of backcrossing and selection using SSR markers. A total of 10 improved HBL 11 lines were subjected to disease screening. Cluster analysis was performed to check the diversity among parents and improved lines. Improved lines of HBL11 with maximum recovery of recurrent parent genome and which showed 0 DMI under screening were crossed with ICMA 97111 to generate improved hybrid versions of HHB 197.

Athoni *et al.*, (2021) developed new hybrid, VPMH-7, was identified by crossing a good combiner and an early flowering A₁ cytoplasm based male sterile line ICMA 94555 with good restorer CPRT 112. The hybrid identified has recorded significantly higher mean yield of 24.50 per cent over National Check, GHB 558, in Zone 3 of Karnataka. Due to its encouraging performance, the hybrid was promoted and tested under Farm Trials and Large-Scale Demonstrations, wherein, the said hybrid recorded 12.60 and 24.80 per cent superiority over GHB-558, respectively. The hybrid is promising for blast disease resistance under field condition as compared to GHB-558, and matures early (80-85 days), making it suitable for late sowing and multiple cropping system. Considering all these attributes, this disease resistant hybrid, VPMH-7, having high yield potential is released (2019) and notified (2020) for commercial cultivation in Zone 3 of Karnataka.

Conclusion

- Downy mildew, Ergot, Smut and Blast are the most destructive diseases of pearl millet and appropriate resistance breeding strategies must be adopted for their management.
- The goodness of fit to 3R:1S segregation ratio in the two F₂s (of C-I and C-II) and 1R:1S ratio in their two backcross populations under both greenhouse and field conditions lead to conclude that foliar blast resistance in the pearl millet lines is controlled by a single dominant gene.
- Understanding genetics of resistance, allelism test inferred the presence of two different genes governing resistance and the usage of resistance sources of diverse origin in breeding programs will help diversify and broaden the genetic base for DM resistance.
- MAS is precise and efficient method for developing host plant resistance. It is the most appropriate approach to manage the disease as it is eco-friendly and cost-effective.

- The newly identified hybrid, VPMH-7 is early variety having high yield and resistant to blast disease, making it suitable for late sowing, intercropping and multiple cropping situations under changing climatic scenario and used for commercial cultivation in Zone-3 of Karnataka.

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