

Privileges of Mutation Breeding in Unfavorable Environmental Stress Conditions

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In recent times, unfavourable environmental conditions have significantly impacted agricultural productivity. Rapid population growth has further intensified the demand for sustainable crop production. Mutation breeding has emerged as an important tool to address these challenges by generating novel genetic variability. This article highlights the role, advantages, and significance of mutation breeding under abiotic stress conditions such as drought, salinity, heat, and flooding. It also discusses its contribution to climate-resilient crop improvement.

Mutation Breeding

In recent years, unfavourable environmental conditions have had a major impact on agricultural production and productivity. With increasing population pressure, ensuring food security has become a major global challenge.

Mutation breeding is one of the promising approaches to address this critical situation. Mutation refers to sudden heritable changes in the genetic material of an

organism. The deliberate use of induced mutations in crop improvement using physical or chemical mutagens such as X-rays and gamma rays is known as mutation breeding (Raina et al.).

Compared to conventional breeding methods, mutation breeding offers the advantage of improving crop performance without significantly altering the original desirable characteristics of the plant. It enables the development of high-yielding varieties with improved resistance to



environmental stresses such as drought and salinity.

Need for Mutation Breeding

Abiotic stresses such as drought, salinity, heat, flooding, nutrient deficiency, and temperature extremes are among the major constraints to crop production. Mutation breeding has an advantage in such situations due to its ability to generate novel genetic variation that may not exist within the natural gene pool of a species.

This is particularly important in horticultural crops, where maintaining consumer-preferred traits such as

flavour, quality, and appearance is essential while improving stress tolerance (Mutanda et al.).

Recent studies suggest that mutation breeding remains an underutilized but highly effective tool for increasing genetic diversity in crops.

Advantages of Mutation Breeding

Mutation breeding enables the rapid improvement of crop varieties already developed through conventional breeding without significantly altering their desirable traits. It helps develop high-yielding, stress-tolerant varieties while maintaining consumer-preferred qualities.

Unlike natural mutation processes, which occur randomly over long periods, induced mutation breeding accelerates the generation of useful genetic variation. This is particularly useful for developing stress-tolerant crops under drought, salinity, heat, and waterlogging conditions (Pagnotta; Doggalli et al.).

Mutation Breeding Under Stress Conditions

Mutation breeding involves the use of physical or chemical mutagens to induce genetic variation in plants. Seeds or plant tissues are exposed to mutagens, resulting in random changes in DNA.

These induced changes can enhance stress-response mechanisms such as ion homeostasis, osmotic adjustment, antioxidant defense, and water-use efficiency, helping plants survive under adverse environmental conditions (Holme et al.).

Abiotic stress tolerance is a complex trait controlled by multiple genes. Mutation breeding is especially valuable because it generates rare and useful variants that are difficult to obtain through conventional breeding methods.

Role in Crop Improvement

Mutation breeding plays an important role in crop improvement due to its compatibility with traditional breeding techniques. Once desirable mutants are identified, they can be stabilized, evaluated, and incorporated into breeding programs (Ali & Talekar; Park et al.).

It also supports climate-resilient agriculture by providing genetic variability for traits such as drought tolerance, salinity tolerance, heat resistance, and waterlogging tolerance (Thingujam et al.).

Thus, mutation breeding serves as an important tool in modern plant breeding strategies aimed at ensuring future food security.

Advantages and Limitations

Despite its usefulness, mutation breeding has certain limitations. Mutations are random in nature, and large populations must be screened to identify desirable traits. Some mutations may be neutral or harmful and may not contribute to crop improvement.

However, mutation breeding remains cost-effective and relatively simple compared to advanced biotechnological approaches. It continues to be widely used for developing improved crop varieties, especially under stress conditions (Holme et al.; Mutanda et al., 2025).

Conclusion

Mutation breeding offers significant advantages under unfavourable environmental stress conditions due to its ability to generate novel genetic variation, enhance resilience, and maintain desirable crop traits. In the context of climate change, it is a valuable approach for developing high-yielding, stress-tolerant, and climate-

resilient crop varieties without adversely affecting environmental sustainability.

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