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Mutation Breeding for Abiotic Stress Tolerance in Wheat

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Mutation breeding is a method used to induce genetic variations, including desirable traits such as abiotic stress resistance, in crop plants like wheat. Abiotic stresses, such as drought, salinity, and extreme temperatures, can have a detrimental impact on crop productivity. By using mutation breeding, researchers can introduce genetic changes that enhance a plant's ability to tolerate or adapt to these stress conditions. Mutation breeding for abiotic stress tolerance in wheat comprises of steps:

1. Mutagenesis: Mutagenesis is the process of introducing mutations into the plant's DNA. In nature, genetic variation primarily arises from mutations. Mutation-based breeding harnesses this process, creating desirable variability not commonly found in nature. This is achieved with the assistance of various physical agents like X-rays, gamma rays, UV light, protons, neutrons, alpha and beta particles, as well as chemical mutagens such as alkylating agents, nitrous acid, acridine, base analogs, azides, and antibiotics. Mutagen treatment induces random changes in the plant's genetic material.
2. Generation of Mutant Population: Seeds or plant tissues of wheat are exposed to mutagenic agents. After treatment, a large population of mutants is generated, each with a unique set of mutations. This population may contain individuals with enhanced abiotic stress resistance due to the random mutations.
3. Screening and Selection: The next step is to subject the mutant population to the specific abiotic stress conditions (e.g., drought, salinity, or heat) against which resistance is desired. The goal is to identify mutants that exhibit improved stress tolerance compared to the non-mutated wheat plants.
4. Characterization: The selected mutants are characterized to understand the genetic basis of their improved stress resistance. This may involve genetic and physiological analyses to identify the specific mutations or genes responsible for the enhanced trait.
5. Breeding and Crop Development: Once promising mutants with improved abiotic stress resistance are identified and characterized, they can be used in wheat breeding programs. These mutants can serve as a source of genetic variation for developing new wheat varieties with enhanced stress resistance. This involves crossing the mutant plants with locally adapted wheat cultivars or other elite lines.
6. Backcrossing and Trait Fixation: Through repeated backcrossing and selection, the desirable trait (abiotic stress resistance) is transferred from the mutant to elite wheat cultivars while maintaining the overall genetic characteristics of the elite lines. This process also helps in reducing undesirable mutant traits.
7. Field Testing: The newly developed wheat lines with enhanced abiotic stress resistance are subjected to field trials to evaluate their performance under real-world conditions.

This ensures that the new varieties exhibit improved stress tolerance without compromising other important agronomic traits.

8. Variety Release: Once the new wheat lines are confirmed to have improved abiotic stress resistance and meet other quality and yield standards, they can be officially released as new wheat varieties for cultivation by farmers.

Mutation breeding for abiotic stress resistance in wheat is a valuable tool in crop improvement, as it harnesses natural genetic variation and introduces random mutations that can lead to novel traits. This approach can help develop wheat varieties that are better equipped to thrive under challenging environmental conditions, ultimately contributing to food security and agricultural sustainability.

Mutation breeding presents no ethical concerns related to human health and sustainability and has become a common tool for enhancing the genetic diversity, making a significant impact. Through mutation breeding, a total of 254 superior bread wheat varieties have been developed and released worldwide, including 26 varieties with enhanced resistance to drought. Notably, Pakistan has seen the release of three economically significant wheat varieties, namely Jauhar-78, Soghat-90, and Kiran-95, developed through induced mutagenesis. In Ukraine, mutation-bred wheat varieties like Kievsky and Novosibivskaya 67 have exhibited improved productivity and resistance to lodging (Zulkiffal *et al*. 2021)

This progress has spurred further research in mutation breeding, particularly in the development of mutant wheat cultivars with traits related to heat and drought tolerance. While challenges exist, such as complex screening of mutants, difficulties in regulating the direction and nature of variations, low occurrence of beneficial mutants, and variable mutagenic efficacy, induced mutations have also proven valuable in creating genetic maps. These maps will facilitate molecular marker-assisted plant breeding, ultimately leading to the development of heat- and drought-tolerant wheat varieties in the near future.

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