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Unleashing Different Types and Future Frontiers of Mutation Breeding

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SUMMARY

Mutation breeding is an exciting technique used in agriculture to create new plant varieties. It involves deliberately causing changes in the genetic material of plants, leading to the development of desirable traits. In this article, we explore different types, characters of mutations and their potential impact on the future of crop improvement. Looking ahead, advances in scientific tools allow us to explore even more possibilities in mutation breeding. With mutation, there occurs changes to the plant's DNA, opening up exciting opportunities for tailored improvements. By embracing genetic diversity and leveraging mutation breeding, we can pave the way for a more sustainable and productive agriculture. This holds tremendous potential to enhance crop traits, strengthen food systems, and create a brighter future for farming.

INTRODUCTION

In the ever-evolving world of agriculture and genetics, mutation breeding stands as remarkable technique for its ability to revolutionize crop improvement. By harnessing the power of genetic diversity, mutation breeding unleashes a vast array of possibilities, offering new horizons for agricultural innovation. Mutation breeding is a captivating process that deliberately induces changes in the genetic material of plants, leading to the emergence of desirable traits. The concept of induced mutagenesis for crop improvement developed dated back to the beginning of 20th century. During the past 80 years, mutation breeding has been successfully utilised for the improvement of crops as well as to supplement the efforts made using traditional methods of plant breeding (Amin *et al*., 2015).

Induced mutation is the ultimate source to alter the genetics of crop plants that may be difficult to bring through cross breeding and other breeding procedures (Khan *et al*., 2004). Therefore, during the last several years, different mutagens have been used by various workers to induce genetic variability in various pulse crops such as Cicer arietinum (Toker *et al*., 2004) Vicia faba (Bond *et al*., 1994). In 1927, Muller showed that X-ray irradiation could considerably enhance the mutation rate in Drosophila. In 1928, Stadler showed the occurrence of a strong phenotypic variation in barley seedlings and sterility in maize tassels after X-ray exposure in combination with radium. Later on gamma and ionizing radiations which constitute the most commonly used physical mutagens like alpha (α) and beta (β) particles and neutrons were developed at newly established nuclear research centers (Mba *et al*., 2012). Whether it's enhancing disease resistance, increasing yields, or improving nutritional content, this technique offers immense potential for transforming agricultural landscapes. The main advantage of mutation breeding is the possibility of improving one or two characters without changing the rest of the genotype.

Mutation: Mutation is a sudden heritable change in DNA sequence which leads to change in characteristics of an organism as classically defined by Hugo de Vries in 1900.
Mutagen: The material used to induce mutation in an organism.
Mutant: An organism or plant which is developed as a result of mutation.
Mutagenesis: Treating a biological material with a mutagen to induce mutation.
Muller and Stadler: The scientists were reported that the mutation can be induced artificially.

Procedure for mutation breeding

- Objectives of the programme: A mutation breeding programme should have well defined and clear-cut objectives.
- Selection of variety for mutagen treatment: Generally, the variety selected for mutagenesis should be the best variety available in the crop.

- Part of plant to be treated: Seeds, pollen grains or vegetative propagules (buds and cuttings) or even complete plants may be used for mutagenesis. Which plant part should be used for `12qwmutagen treatment depends primarily on whether the crop is sexually or asexually propagated and on the mutagen to be used.
- Dose of mutagen: The most appropriate plant or stage to be treated requires a thorough knowledge of the organisms and a clear definition of experimental objectives.
- Giving mutagen treatment: The selected plant part is exposed to the desired mutagen dose.
- Handling of the mutagen treated population: Treatment of seeds and vegetative propagules commonly produces chimaeras, which should be handled properly.

Major types of mutation:

Spontaneous mutation:

Mutation occurs in natural populations (without any treatment by man) at a low rate; known as Spontaneous mutation. The frequency of Spontaneous mutation is generally one in 10 lakhs, *i.e.* 10^{-6}.

Induced mutation:

- The mutation may be artificially induced by a treatment with certain physical or chemical agents known as Induced Mutation.
- Agents used for producing them termed as Mutagens.
- The utilisation of induced mutation for crop improvement is known as Mutation Breeding.
- Induced mutations have a great advantage over the spontaneous ones; they occur at a relatively higher frequency so that it is practical to work with them.

Other types of mutation:

Chromosomal mutation: A mutation involving a long segment of DNA. These mutations can involve deletions, insertions, or inversions of sections of DNA. In some cases, deleted sections may attach to other chromosomes, disrupting both the chromosomes that loses the DNA and the one that gains it. Also referred to as a chromosomal rearrangement.

Cytoplasmic mutation: Mutation which occurs in cytoplasmic cells.

Somatic mutation: the occurrence of a mutation in the somatic tissue of an organism, resulting in a genetically mosaic individual.

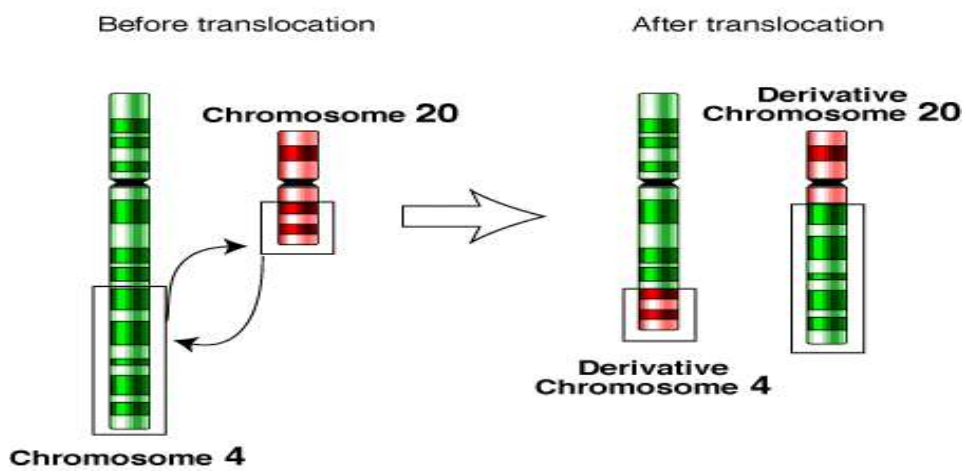
Chromosomal aberrations

1) Numerical- Change in the number

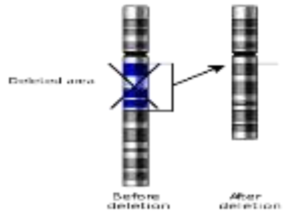
2) Structural- Change in the structure

Structural aberrations

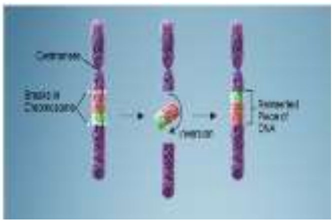
Translocation: These are the chromosome mutations in which chromosome segments, and the genes they contain, change position.



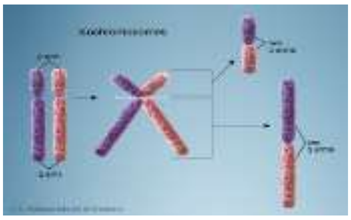
Deletion: A deletion mutation is a mistake in the DNA replication process which removes nucleotides from the genome.



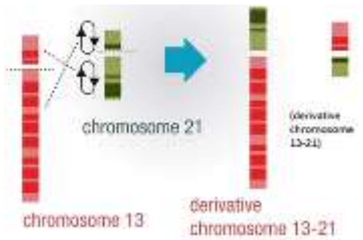
Inversion: An *inversion* is a chromosome rearrangement in which a segment of a chromosome is reversed end to end.



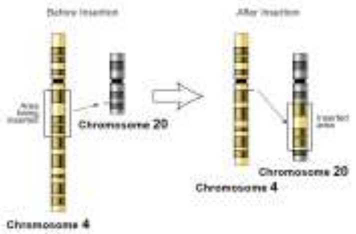
Isochromosomes: An *isochromosome* is an unbalanced structural abnormality in which the arms of the chromosome are mirror images of each other.



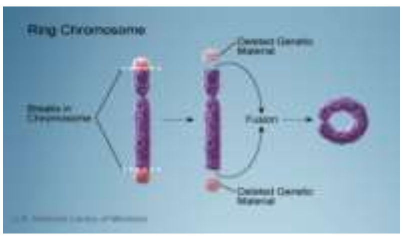
Derivative chromosome: A *derivative chromosome* is a structurally rearranged *chromosome* generated either by a *chromosome* rearrangement involving two or more *chromosomes*.



Insertions: In genetics, an *insertion* is the addition of one or more nucleotide base pairs into a DNA.



Ring chromosome: A *ring chromosome* is an aberrant *chromosome* whose ends have fused together to form a *ring*.



Chimeras
Chimera is a single organism or a plant species composed of cells with distinct genotypes.
Types of chimeras:
Periclinal chimera: These are most important category since they are relatively stable.
Mericlinal chimera: A mutated cell do not civer entire partof apical meristem.
Sectorial chimera: It affects sections of apical meristem.

Characteristics of mutation

- Mutations are generally recessive. But dominant mutations also occur.
- Most of the mutations have deleterious effects, but a small proportion is beneficial.
- Mutations are random. They may occur in any genes.
- Mutations are recurrent. Same mutations occur repeatedly.
- Commonly show pleiotropy.

According to types of cells in which mutation occurs
Somatic mutation: Mutations occurring in body cells. These are not transmitted to next generation and hence termed as non-heritable mutations.
Germinal mutation: Mutations occurring in reproductive cells and such mutations are heritable and passed on to next generation.

On the basis of origin (mode of Origin)
a.Spontaneous mutations or Natural Mutations: Spontaneous mutation:When mutations occur naturally. Eg: Double petunia -Freaks appearing in a population
b. Induced mutation: Produced artificially in the laboratory. Muller with X-rays produced mutants in *Drosophilla*.

Mutations based on their directions
a. Forward mutation: Development of a new mutant type from a wild type (normal type).
b. Reverse mutation: Back mutation Mutants revert to normal type

Based on affecting factors
Endogenous mutation: Caused by certain internal factors like change in metabolism, nutrition *etc*.
Exogenous mutation: Caused by external factors like change in temperature, climate *etc*.

Nature of mutations
Gene mutation: a change in the DNA molecule of an individual gene
Chromosomal mutation: Due to changes in the structure of chromosome.

Advantages of mutation:
- Increased yield.
- Increased resistance.
- Improved seed character.
- Improved agronomic characteristics.
- Improved lodging resistance.
- Shortened maturity time.

Future scope for mutation breeding:
The future scope of mutation breeding holds immense promise for agricultural advancements and addressing global challenges. Here are some key aspects of its future scope:

- Genetic Innovation: Mutation breeding will continue to serve as a powerful tool for introducing novel genetic variations in crops, leading to the development of improved traits such as disease resistance, drought tolerance, and nutritional content. This can contribute to enhanced crop productivity and quality.
- Sustainable Agriculture: With a growing need for sustainable farming practices, mutation breeding offers a potential solution. By developing crops with increased resilience to environmental stresses, reduced dependence on pesticides, and improved resource-use efficiency, mutation breeding can support sustainable agricultural systems.
- Climate Change Adaptation: As climate change impacts agriculture, mutation breeding can play a crucial role in developing climate-resilient crops. By introducing genetic variations that enhance tolerance to temperature extremes, water scarcity, and pests, it can help farmers adapt to changing environmental conditions.
- Food Security: The increasing global population poses challenges to food production. Mutation breeding can contribute to ensuring food security by developing high-yielding crop varieties that are adapted to diverse agro-climatic conditions, allowing for increased agricultural productivity.
- Nutritional Enhancement: Mutation breeding can be utilized to enhance the nutritional content of crops, addressing nutritional deficiencies and promoting healthier diets. By increasing the levels of vitamins, minerals, and other beneficial compounds in crops, it can help combat malnutrition and improve public health.
- Integration with Biotechnology: The integration of mutation breeding with advanced biotechnological tools, such as gene editing techniques like CRISPR-Cas9, holds significant potential. This synergy can facilitate precise modifications in crop genomes, accelerating the development of desired traits with greater efficiency.
- Overall, the future scope of mutation breeding is exciting, offering opportunities for sustainable agriculture, climate resilience, improved nutrition, and global food security. By harnessing the power of genetic diversity, mutation breeding can contribute to addressing critical challenges and shaping a more resilient and productive agricultural future.

CONCLUSION

Mutation breeding is a powerful technique that holds immense potential for revolutionizing agriculture. By inducing genetic changes in plants, it offers a pathway to developing desirable traits. Through exploring different types of mutations, we have witnessed the possibilities of enhanced disease resistance, increased yields, and improved nutrition. The future frontiers of mutation breeding, fueled by advances in molecular techniques and gene editing, promise even greater advancements. Embracing genetic diversity and innovation, mutation breeding can contribute to sustainable agriculture, climate resilience, and global food security. It empowers us to shape a brighter future where crops thrive in the face of challenges, ensuring a prosperous agricultural landscape.

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