International Journal of Horticulture and Food Science

E-ISSN: 2663-1067
P-ISSN: 2663-1075
NAAS Rating (2025): 4.74
www.hortijournal.com
IJHFS 2025; 7(8): 75-80
Received: 05-06-2025
Accepted: 07-07-2025

Sabira M
M.Sc., Department of Vegetable Science, College of Agriculture, Vellayani, Kerala Agricultural University, Kerala, India

Shruthy ON
Assistant Professor, Department of Vegetable Science, College of Agriculture, Vellayani, Kerala Agricultural University, Kerala, India

Corresponding Author:
Sabira M
M.Sc., Department of Vegetable Science, College of Agriculture, Vellayani, Kerala Agricultural University, Kerala, India

Mutation breeding: A tool for crop improvement in vegetable crops

Sabira M and Shruthy ON

DOI: https://www.doi.org/10.33545/26631067.2025.v7.i8b.367

Abstract
With the surging global population, decreasing arable farmland area and deteriorating environment, there is a strong requirement. For multiple breeding approaches to reduce the crop breeding cycle and to augment breeding efficiency with high productivity to meet the global food demands. Mutation breeding is one of the pivotal techniques for inducing novel variations in traits such as earliness, high yield, quality, breaking undesirable linkages, pest and disease resistance that leads to fasten the crop breeding cycles.

Keywords: Mutagens, procedures, applications, modern trends

Introduction
History of mutation
Mutation, the term coined by Hugo de Vries in 1900 to describe heritable phenotypic alternations. Following Wilhelm Roentgen's 1895 discovery of X-rays, Muller (1927) and Stadler (1928) used X-rays to persuade mutations in *Drosophila melanogaster* and barley, respectively. One of the earliest milestones in crop mutation was the development of the chlorina mutant in *Nicotiana tabacum* (tobacco), marking the first commercially used mutant variety. Later, the induction of powdery mildew resistance in barley by X-ray was reported by Freisleben and Lein in 1942. A landmark contribution came from Gustafsson in 1947, whose work showed that a wide range of mutations in barley especially those affecting chlorophyll and stem stiffness (erectoides) responded differently depending on the plant genotype and environmental conditions. His research played a crucial role in shaping the field and is often credited as the driving force behind the growth of mutation breeding. For his pioneering efforts, Gustafsson is widely regarded as the Father of Mutation Breeding**.**

Mutation & Mutation Breeding
Mutation is any sudden, heritable alteration in an organism's genome that is neither the result of regular recombination nor segregation. Mutation breeding refers to the process of genetically modifying crop plants for a variety of economic traits through the use of induced mutations. Its main objective. is to create wide variation within the population. There are different types of mutations based upon certain factors. Mutations that occur naturally are spontaneous mutations whereas induced mutations are those that are created artificially by the use of specific physical or chemical agents. Among different types of mutations, induced mutation is used for the genetic improvement of various crops.

Mutagens
The term "mutagen" refers to substances that cause mutations. It can be induced by physical and chemical agents. Its classification is listed in fig 1.

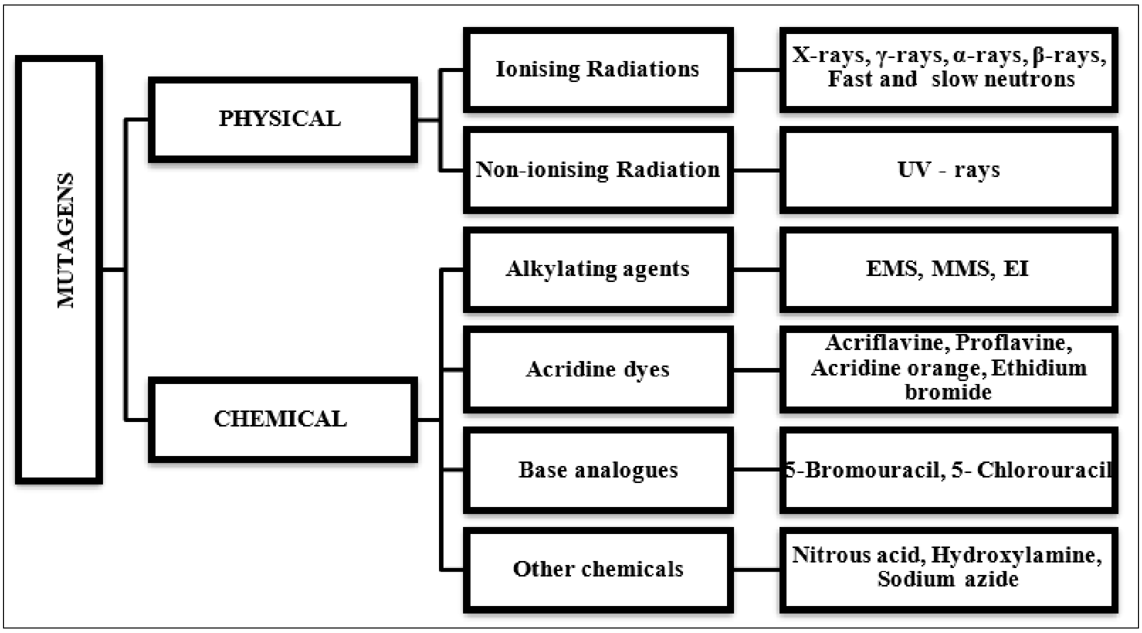


Fig 1: Classification of Mutagens

Lethal dose 50 (LD 50)

The lethal dose 50 provides insight into the ideal mutagen dose. It is the dose of mutagen which would kill 50% of the treated individuals. An optimal dosage induces maximum mutations with minimal detrimental effects. A high mutagen dose will kill an excessive number of plants, whereas a low dose will result in an insufficient mutation spectrum and frequency. The concentration, treatment time, and treatment temperature are the key determinants of the mutagenic dosage. LD 50 values for gamma irradiation in various vegetables are given in table 1.

Table 1: LD 50 doses of gamma irradiation of some important vegetables

Crop	Gamma radiation dose (kR)
Potato	5-6
Tomato	15-25
Brinjal	20-30
Onion	10-15
Cucumber	25-40
Okra	30-60
Brassica sps	60-80

Effect of mutagens in vegetable crops

Physical mutagens

In most applications, γ-ray and fast neutron bombardment are currently outperformed by other radiation-based techniques. Of these, gamma ray irradiation generates point mutations, small deletions and is less destructive whereas fast neutron irradiation causes translocations, chromosome losses and massive deletions. Exposure time of physical mutagens also affects how it effectively cause mutation. According to research by Falusi *et al.* (2012) [3] showed that treating *Capsicum annuum* and *Capsicum frutescens* with fast neutrons for 90 minutes resulted in the highest yield performance. Similarly, a study by Mohite and Gurav (2019) [101] found that 50 kR gamma ray treatment in okra produced the most promising results in both the M1 and M2 generations.

Chemical mutagens

Chemical mutagens have proven effective in mutation breeding programs, helping to create genetic variations that lead to improved crop varieties with traits such as higher yield, reduced stature and better disease resistance. An experiment conducted by Reddaiah *et al.* (2014) [12] on induced mutation in *Solanum lycopersicum* cv. Arka Vikas using EMS (0.75%) found to obtain more number of genetic variability. Additionally, a comparative study conducted by Awachar *et al*. (2022) [2] on two *Capsicum annuum* L. varieties Pusa Jwala and Pusa Sadabahar in the M2 generation revealed that sodium azide was more effective than hydroxylamine in inducing desirable morphological changes and enhancing genetic diversity.

Procedure for mutation breeding

The entire process of using a mutagen on biological materials to create a desirable mutant phenotype is referred to,as mutation breeding. The various processes in mutation breeding are given in fig.2:

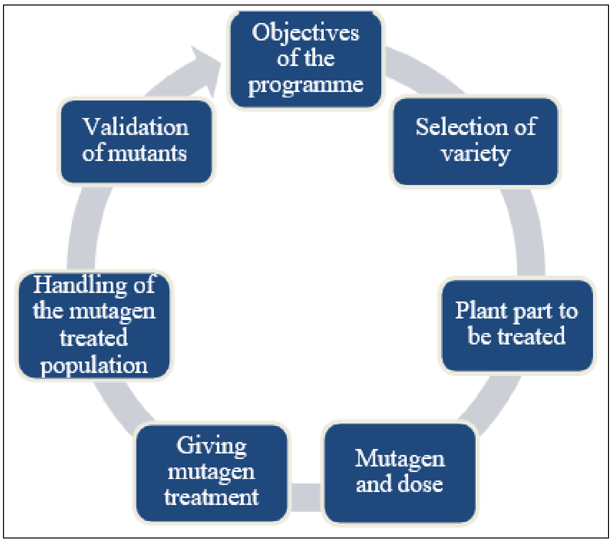
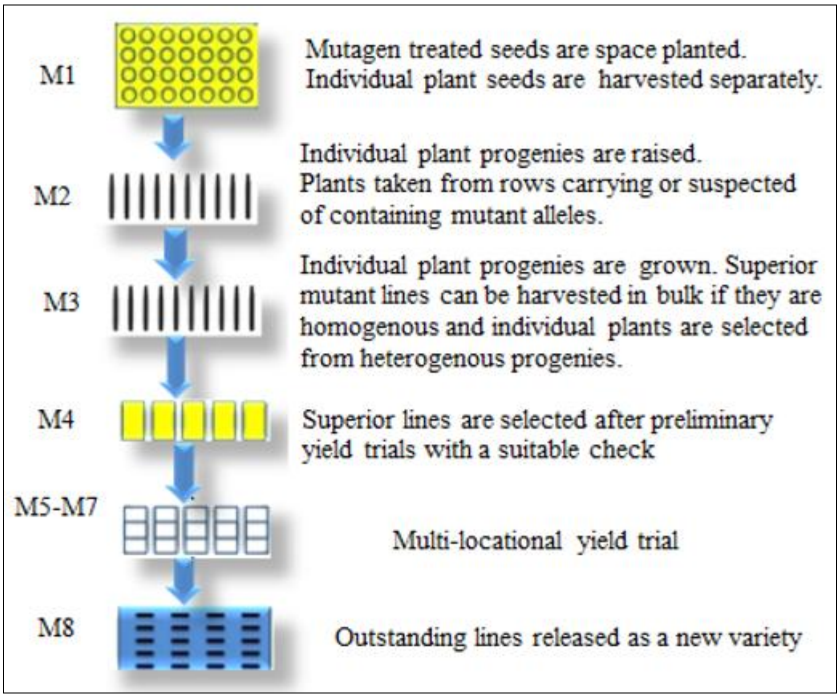


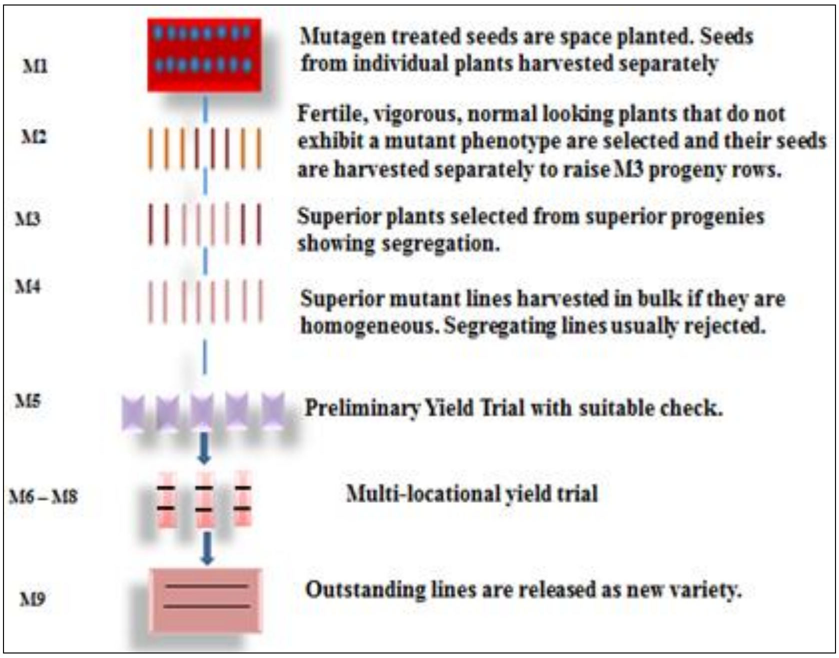
Fig 2: Procedure for mutation breeding

Both dominant and recessive mutations are exist. From the first generation of mutation itself, dominant mutations can be selected. But selection for recessive mutations should begin from second mutant generation. Mutation will have an effect on both polygenic and oligogenic traits. It helps to broaden the genetic variability using physical and chemical mutagens for improving crop productivity in both seed-based and vegetatively propagated crops Sarkar *et al*. (2024) [6].

Mutation breeding in sexually propagated plants.
Mutation breeding for oligogenic traits



Mutation breeding for polygenic traits



Applications of mutation breeding

Mutation breeding is extensively employed to introduce favourable traits in crops. Its main objective is to obtain more variation among the population and to improve various qualitative and quantitative traits like growth, yield, quality, biotic and abiotic stress resistance, breaking undesirable traits etc. Luan *et al.* (2007) [8] screened sweet potato mutants for salt tolerance and reported that mutants treated with EMS 0.5% for 2 and 2.5 hours tolerated more in saline condition. Induced mutation creates new variation in genes and advanced modern approaches utilize mutated plants for breeding purposes as well as for creation of mutation library which can be utilized for both forward and reverse genetics studies (Tadmor *et al.*, 2007) [13]. Anjitha, okra variety developed by KAU through induced mutation, in interspecific hybrids of *Abelmoschus esculentus.* var.

Kiran and *A. manihot* found to break its undesirable linkage by irradiation (Manju and Gopimony, 2009) [10]. In peas (*Pisum sativum*), Khan *et al.* (2018) [5] reported that lower doses of gamma irradiation improved morphological traits and yield components in the M2 generation. A study conducted by AL-Kubati *et al*., (2022) [1] discovered that bottle gourd plants treated with EMS developed stronger resistance to cucumber green mottle mosaic virus, with reduced disease severity in mutated plants. These examples demonstrate how mutation breeding effectively enhances genetic variation, leading to the development of superior crop varieties suited to modern agricultural challenges.

Modern trends in mutation breeding

In vitro mutagenesis

The plant breeders has access to a variety of *in vitro* techniques such as micropropagation, protoplast culture, embryo rescue, and somatic embryogenesis to enhance the efficiency of creating, selecting, and multiplying desirable plant traits. Combining mutagenesis with tissue culture is a highly effective approach to boost genetic variation, which breeders can use for crop improvement. One of the major benefits of *in vitro* mutagenesis is the ability to expose large numbers of cells, protoplasts, or somatic embryos to mutagens in a controlled environment. This method allows for:

- Faster multiplication of mutant plant material
- Early selection of useful mutations *in vitro*
- Space-saving shoot multiplication under controlled conditions
- Efficient screening for resistance to diseases, pests, drought, and salinity

Mutant clones developed through this method often show enhanced resistance to both biotic and abiotic stresses. For instance, Hadi and Fuller (2013) [4] reported that induced cauliflower mutants, treated with chemical mutagens like NEU and NMU, maintained stable resistance to drought and salt stress even after regeneration and micropropagation.

Space breeding

Strong cosmic radiation, microgravity, weak geomagnetic fields, and a super-clean super-vacuum create a unique atmosphere in space. A significant amount of experimental data demonstrated that the environment in space has an impact on plant growth and development as well as causing genetic variations in crop seeds. Space-induced mutation is an effective technique for creating new crop varieties as well as rare mutants that may significantly improve key economic traits like yield, and quality that are difficult to obtain through traditional breeding, methods on the ground (Liu, 2009) [7].

High throughput screening method

A number of efficient, accurate, and systematic breeding techniques have been developed recently as a result of the development of modern high-throughput instruments and their combination with molecular labelling technology. These techniques can be used for the high-throughput identification of genotypes and phenotypes of mutagenized populations for consecutive generations. In particular, multispectral imaging and machine vision technologies, combined with image processing, have greatly enhanced the speed and accuracy of phenotype detection. These innovations help breeders spot useful mutations faster, making the selection process much more effective (Ma *et al*., 2021) [9].

Tilling

The mutation techniques along with molecular technologies like high-throughput mutation-screening techniques are getting increasingly potent and effective at creating new varieties. With the advancement of modern biotechnology and the genomic discoveries of crop plants, particularly with the advent of targeted induced local lesions in genomics (TILLING) technology, mutation breeding could become, a productive strategy to complement other technologies in vegetable breeding. TILLING is a high-throughput, technology that uses a potent detection method to find single nucleotide mutations in a targeted area of a gene of interest caused by chemically induced mutagenesis. It is fast, efficient, and cost-effective, making it ideal for screening large populations of mutagenized plants to find desirable point mutations (Wang *et al*., 2006) [14].

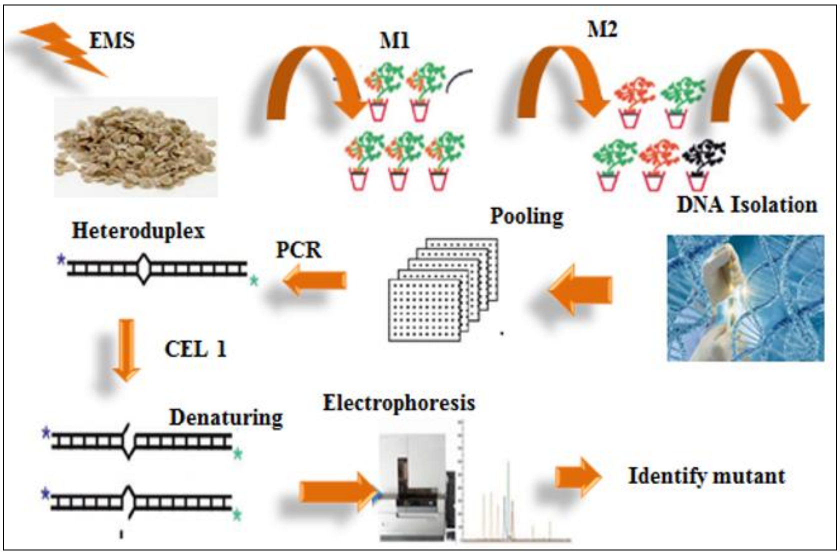


Plate 1: Procedure of TILLING

Mutant varieties database

The Joint FAO/IAEA maintains the Mutant Variety Database (MVD), which is a global resource that records information on officially released mutant crop varieties, including both seed-propagated and vegetatively propagated plants. It gathers data on agricultural mutant varieties, mutagens used and its improved traits. It serves as a valuable tool for researchers and breeders by providing scientific data on crop mutant varieties that can be used in breeding programs and genetic studies. It includes more than 200 different types of crops and 3400 different varieties released from 70 different countries and list of new varieties that are contributed from various countries.

Plate 2: Mutant Varieties Database

Conclusion& Future thrust

Plant breeders have been compelled to devise policies to improve the quantitative, and qualitative features of edible crops as, a result of rising food insecurity, particularly in emerging nations like India. Induced mutagenesis has been demonstrated in numerous studies to be an effective technique for a balanced rise in the targeted characteristic, in addition to yield and its attributing characters. A particular benefit of mutation induction is the creation of a variety of mutant lines, the identification of trait-specific genes, the study of molecular functional, genomics, and the development of bio-informatics for the creation of plant varieties to be grown on the available arable land under climate change to feed the rapidly increasing human population. When guided by clear goals, a well-designed mutagenic protocol, and effective screening methods, mutagenesis can be a valuable technique for crop improvement. Furthermore, integrating mutation breeding with modern genetic engineering and molecular mapping can significantly accelerate the development of high-yielding, climate-resilient plant varieties. These combined tools are likely to become essential in the future of plant breeding.

References

1. AL-Kubati AMS, Kang B, Abbas A, Kaseb MO, Gu Q. Screening for resistance to cucumber green mottle mosaic virus in bottle gourd mutated by Ethyl methanesulphonate. Aust Plant Pathol. 2022;51(5):535-41.
2. Awachar SR, Parveen S. Induction of genetic variability in Pusa Jwala and Pusa Sadabahar (*Capsicum annuum* L.) through Mutation via Sodium Azide and Hydroxyl Amine. YMER. 2022;21(6):313-8.
3. Falusi OA, Daudu OAY, Teixeira da Silva JA. Effect of exposure time of fast neutron irradiation on growth and yield parameters of Capsicum annum and Capsicum frutescens. Afr J Plant Sci. 2012;6(9):251-5.
4. Hadi F, Fuller MP. Chemically induced mutants of *Brassica oleracea* var. botrytis maintained stable resistance to drought and salt stress after regeneration and micropropagation. Am J Plant Sci. 2013;4(3):498-507.
5. Khan WM, Muhammad Z, Akhtar N, Burni T, Younas A, Umar N. Gamma radiation induced mutation in M2 generation of Pea (*Pisum sativum* L.). Pure Appl Biol. 2018;7(2):832-9.
6. Sarkar T, Mondal T. Recent advances and achievements in mutation breeding of fruit crops. Int J Agric Food Sci. 2024;6(2):166-72.
7. Liu LX, Guo HJ, Zhao LS, Wang J, Gu JY, Zhao SR. Achievements and perspectives of crop space breeding in China. In: Induced plant mutations in the genomics era. Rome: Food and Agriculture Organization of the United Nations; 2009. p. 213-5.
8. Luan YS, Zhang J, Gao XR, An LJ. Mutation induced by ethylmethanesulphonate (EMS), *in vitro* screening for salt tolerance and plant regeneration of sweet potato (*Ipomoea batatas* L.). Plant Cell Tissue Organ Cult. 2007;88:77-81.
9. Ma L, Kong F, Sun K, Wang T, Guo T. From Classical Radiation to Modern Radiation: Past, Present, and Future of Radiation Mutation Breeding. Front Public Health. 2021;9(1):768071.
10. Manju P, Gopimony R. Anjitha-A new okra variety through induced mutation in interspecific hybrids of *Abelmoschus* spp. In: Induced plant mutations in the genomics era. 2009. p. 87-90.
11. Mohite AV, Gurav RV. Induced mutation using gamma rays in okra (*Abelmoschus esculentus* (L.) Moench). J Appl Hortic. 2019;21(3):205-8.
12. Reddaiah B, Sudarsanam G, Sreelakshmi Y, Sharma R.

Generation of Ethyl methane sulphonate (EMS) induced mutant population of *Solanum lycopersicum* cv. Arka Vikas. Int J Plant Anim Environ Sci. 2014;1(4):212-8.

13. Tadmor Y, Katzir N, Meir A, Yaniv-Yaakov A, Saar U, Baumkoler F, *et al*. Induced mutagenesis to augment the natural genetic variability of melon (*Cucumis melo* L.). Isr J Plant Sci. 2007;55(2):159-69.
14. Wang DK, Sun ZX, TAO YZ. Application of Tilling in plant improvement. Acta Genet Sin. 2006;33(11):957-64.