REVIEW ARTICLE

A REVIEW ON OVERVIEW ROLE OF MUTATION IN PLANT BREEDING

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ABSTRACT

Genetic diversity is the basis for plant breeders to develop new and improved cultivars with desirable, suited, and adaptive characteristics. Several factors such as hybridization, recombination, and mutation (Spontaneous and induced) are useful measures for providing variation in plants. However, naturally occurring mutation rate offers less for their optimum utilization. Hence induced mutation is considered to be a prime alternative other than naturally occurring variation. It has been considered a verified way of creating new variation within a crop variety which offers a possibility for the induction of desirable attributes which either can't be expressed in nature or have been faded away during the process of evolution. Some of the mutant varieties of several crop species have led to a global contribution to crop improvement. The fate of the induced mutation largely depends on how induced mutagenesis underpins plants' functional genome. Plant mutagenesis has already played a significant role in crop improvement by successful enhancement of the yield, better nutritional quality, and wider adaptability. This review article is primarily centered around mutation, selection of mutant, how and when to use induced mutation, their treatment dose, and roles of mutation in Plant Breeding. Lastly, there still lies a huge potential aspect for future crop improvement through the application of induced mutation in plant species. In barley, a mutant that is resistant to mildew was 1st recorded in 1942. From the 170 diverse plant species, 3222 mutant varieties are evolved in 60 countries across the world officially. That release of varieties is possible due to the extensive use of induced mutation for 50 years in plant breeding activities all over the world. The modification of the nucleotides sequence of the genetic material of an organism, virus, extrachromosomal DNA is called a mutation. Mutagen is the agent causing mutation. There is extensive use of mutants in different subjects such as genetics, plant breeding, and plant physiology. Hugo de Vries coined the term 'mutation' in 1901 to show sudden alteration in character considered to be heritable. Hence transmittable to the offspring while an agent causing mutation is called a mutagen. Mutation can occur naturally (spontaneous mutation) or by different agents such as chemical mutagen, ultraviolet light, x-rays, gamma rays, and so on (induced mutation). Mutagenesis is defined as the process in which the genetic information of an organism changed in a stable manner resulted in mutation.

KEYWORDS

mutation breeding, Mutant plant, mutagenesis.

1. MUTATION: A GENERAL OUTLOOK

Macro and micro mutation are the two groups from which mutations are categorized phenotypically. The mutation which is easily detectable in individual plants, morphologically distinct and phenotypically viewable, occurs in major genes or oligogenic and genetic changes inherited qualitatively is called a macro mutation. The micro mutation resulted in a small effect. Generally, it can be recognized only with the help of statistical methods in which genetic changes inheritance quantitatively. It is present in minor genes or polygenes.

There is a change in genetic material at three different levels (Sigurbjörnsson, 2012):

- 1) At gene level (gene mutation)
- 2) At the chromosomal level
- 3) At the genomic levels such as aneuploidy or polyploidy.

The spontaneous mutation is the result of errors in natural biological processes where there is no interference from humans. With the introgression into wheat and rice of spontaneous mutant allele of a gene results, the green revolution. The mutation that promoted domestication is: In Almond, watermelon, potato, and eggplant there is the elimination of bitterness and toxicity (Mba, 2013). There is the elimination of the need for sexual reproduction in certain fruits like banana, grape, orange, etc. Loss of outer hard seed coat and other various germination inhibitors (wheat, barley). There are different methods of irradiation. The seed exposed to the radiation for annually propagated crops became a more or less classical method of mutation induction due to easy uniformity, insensitivity to the storage, and the possibility for delivery of dry seed over a long route (Micke et al., 1990). Another method is pollen irradiation where pollen exposes to radiation.

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The controversy persists whether the usable gene mutation is inferior or superior to seed irradiation. The variations other than due to natural causes are incorporated through induced mutation, is considered the source of germ plasm for various plant improvements activities. It is also an alternative to hybridization as well as in plant breeding recombination. Common mutagen occurring in nature is :- a) Physical mutagen: x-rays, gamma rays, UV radiation, β particles, neutrons. b) Chemical mutagen: base analogue, alkylating agent, azides, hydroxyl amine, nitrous acid. In general, ionizing radiation with easy application, high mutation frequency, good penetration, productivity and less disposal problems are preferred to induce mutation. Widely used radiations are X-rays, gamma rays (Solanki et al., 2011). In China, 1957, the first varieties of rice, KT 20-74 and SH 30-21, were developed through induced mutation, were released. The first variety Yenhsing-1, was developed by a series of cross-breeding programmed with a mutant. Soon afterwards, Japan released the semi dwarf mutant Reimei which significantly increased the performance and yield because of their lodging resistance ability.

Calrose 76 and Basmati 370, semi dwarf varieties of rice had short and stiff straw has revolutionized the yield and production of rice in USA and Pakistan as well. In Pakistan, a new variety 'Kashmir Basmati' had a shorter maturing duration, has cold tolerance, and retains the significant aroma and cooking quality of its parent, was derived from induced mutation in Basmati 370. Several other high yielding rice mutants were released in India under the series PNR and some of these were early in maturity but had relatively shorter height. Among these, two varieties with shorter duration and aromatic mutation-derived rice varieties, PNR-381' and 'PNR- 102', are popular for cultivation in Haryana and Uttar Pradesh. A Rice mutant 'Zhefu 802' was cultivated on more than 10.6 million ha in China for more than 10 years. In Thailand, use of gamma ray irradiations to release an aromatic indica variety of rice 'RD6' in 1977 was achieved. This variety was extensively grown on 2.4m ha during the year 1994-95. Similar mutant 'RD15', was released after 3 years which was grown over 0.2 million ha, equivalent to 3.2% of the area under rice (Forsyth, 1995). Similarly, in Australia nine rice mutant varieties have been developed using induced mutation techniques. Mutation induction has become an established tool and one of prime aspect in plant breeding to supplement existing germ plasm and to improve the performance of cultivars through certain specific traits.

Spontaneous mutations could be used only to restricted cases, mainly in vegetatively propagated ornamentals or fruit crops, since their frequency is far too low for the advancing genetic improvement expected from plant breeding. No qualitative difference between spontaneous and induced mutations is found. Hence, a major advantage of mutation induction is the wider possibility of obtaining unselected genetic variation, whereas the available germ-plasm has already passed through an effective selection screens by either nature itself or man. Mutations can be induced in any gene however at different probabilities. In the initial phase, mutation breeding was based primarily upon x-rays, but now mainly gamma rays and to a minor extent some fast or thermal neutrons are also in use. However, certain disappointment about the detrimental effects of ionizing radiation has forced some researchers to put their hopes rather upon chemical mutagens. As far as radiations are concerned, national and international rules are followed to safeguard radiation facilities and established standards for safe handling. The wider ranges of chemical mutagen have hindered the process of establishing sets of common rules, although its need have been recognized. The chemical mutagen were expected /preferred over physical mutagens by breeders have led to widespread use of chemical.

But these optimistic expectations faded away with time and now chemical mutagens are considered to be one of several means for inducing genetic variation. Higher mutation frequencies which are observed from treatment with certain "super-mutagens" appear as not desirable because of its multiple mutation induction, requiring plenty time-consuming recombination and separation of mutant genes by cross breeding. Those crops propagated from seeds and often resting on seed irradiation almost have become a classical method of mutation induction because of easy standardization, low sensitivity to storage and possibility for transport of

dry seeds over long distances. There still remains a consistency about if results in terms of usable gene mutation are superior or inferior to radiation. The use of chemical mutagen was less in practical for vegetatively propagated plant because of difficulties in determining dose for the targeted cells, soaking requirements, inadequate mutagen penetration and so on. As a result, both irradiations as well as chemical mutagen treatment of vegetatively propagated plants tend to be a special artwork for specialized institutes and their highly qualified breeders.

2. HOW TO SELECT A MUTATION?(SIGURBJÖRNSSON, 2012)

In the beneficial cost/benefit ratio, desired mutation retrieval is important, which depends on the handling of the treated material in a large amount, and then, a selection method is used. First, take an account of breeding objectives, in which all the seeds should be harvest and single seed per plant, or one or more reproductive organs per M1 plant from M1 plants, is pronounced. Consequently, the M2 generation can be grown, as a cost-saving bulk or planted in progenies i.e. plant- to-row, spike-to-row, fruit-to-row. The better recognition of mutant segregation is allowed by progenies but in the bulk population visible in different mutants may also be easily detected. The self-pollination in M1 plants will cause segregation, which leads to homozygous mutants in the M2 generation in the case of diploid hermaphrodite species. However, some degree of sterility found in M1 plants increases the potential out-crossing, even in species that classify as obligate self-pollinators. That's why spatial isolation or bagging is necessary to measure used in the M1 generation.

M2 progenies of 20 plants are sufficient to obtain a certain number of segregates which are homozygous for a mutant trait in the case of diploid species. However, for quantitatively inherited characters and polyploidy, it would be advantageous to allow more recombination to take place by delaying selection to the M3 generation. Due to the absence of the heterozygous fraction of the population, the selection will be much facilitated especially for quantitatively inherited traits, if a doubled-haploid system is used. The chimeric structure of M2 plants does not allow self-pollination within a mutated sector in diclinous species like maize so that there is no segregation of homozygous mutants in M2. The practical procedure is inter-pollination of M1 plants bring all induced mutations into heterozygous M2 plant and also an alternative method would be the mutagens treatment of pollen and pollination of non-treated mother plant leads to non-chimeric M1 plants that are heterozygous for the induced mutation. Then these plants should be self-pollinated for obtaining homozygous mutants.

Some form of recurrent selection is involved in self-incompatible mutation breeding or cross-pollinated species. Concerning the selection of induced mutation, there is a difference between vegetatively propagated plants from a seed propagated plant. Ultimately, the only mutation that is occurred in the sporogenous tissue passing through the meiosis is transmitted to the progeny. On the contrary, a mutation-induced in somatic cells that are effective in forming a somatic descendent may be evident in a clonally propagated new organism. The selection of mutants starts in the MtV2 generation. To confirm the mutant characteristics, an observation in MtV3 is done in which each selected variant has to be further propagated. One has to evaluate the stability and uniformity of the clone in MtV4 generation and the subsequent generation. Uniform and stable clones are only planted for agronomic evaluation.

3. HOW TO USE INDUCED MUTATIONS

The induction of mutations leads to variability and does not require any improvement. There is no guarantee that a 'mutant plant' has only one genetic mutation. Conversely, there may be many induced mutations as the useful strains available today and several thousand genes are exposed to the mutations. One or two may be noticed, but most do not. Therefore, where possible, it is better to 'back cross' the selected mutants to its original parent and to match the 'refined' desired mutants. This process at the same time provides valuable information about the inheritance of the clumsy character and provides additional assistance in removing contaminants (extra compounds or exteriors).

In order to fully exploit the potential for mutation, the mutation of mutated genes into different genetic backgrounds must be seriously considered. A whole series of successful cultivars, often revealing surprising features, have been created by cross-breeding with mutants. Genetically modified plants are primarily used for advanced clonal cultivation. Mutations involving the use of mutants as parents in crosses involve the LII histogenic layer, which causes sporogenous tissue to form. Passing the mutants may eventually lead to the reunification of the mutated genes, but at the same time destroy the original valuable gene that the breeder wanted to maintain. This has several important implications: First, the amount of mutation should not be too large to avoid multiple mutations occurring. Second, one must target several similar mutations to choose from. Chimeric mutants should not be static and thus mutations cannot be passed on to their descendants; therefore solid (non-chimeric) mutated clones with genetically uniform histogenic layers are highly desirable. The mutant clones made from adventitious buds are mostly non-symmetric. However, mutagenic treatment can also be applied to the posterior-connective tissue of a chimera, e.g. Bringing a mutated LI layer into the LII layer and vice versa eventually leads to non-symmetric (homohistont) shooting.

4. RECOMMENDED DOSE FOR SPECIES MODIFICATION

The mutation rate, or mutation frequency, i.e. number of mutant plant per M2 lines (Metalized 2nd generation), is generally calculated per dose and compared which radiation or mutagen would be better from the aspect of the Radiation Biology (Tanaka et al., 2010).

Species	Material	Mutagen	Recommended dose
Cicer araeinum	dry seed	X- rays	10-16 krad
Glycine max	dry seed	Gamma rays	10-20 krad
Lycopersicon esculentum	dry seed	EMS	0.8%, 24 H, 24 C
Zea mays	dry seed	Gamma rays	14-28 krad
Pisum sativum	dry seed	X- rays	10 krad
Triticum astivum	dry seed	Gamma rays	10-25 krad
Avena sativa	dry seed	X rays	12-24 krad
Hordeum vulgare	dry seed	X-rays	10-22 krad
Oryza sativa	dry seed	X- rays	14-28 krad

5. WHEN TO USE INDUCED MUTATION

Frequently, a plant grower begins to think of sophisticated approaches such as remote hybridization or mutation induction, often observed when he realizes that he has exhausted the ability to select from natural populations and reunite with cultivators. Ideally / the grower should be aware of the possibilities and limitations of different approaches and deliberately choose the most appropriate and economical one to achieve the objectives in the current scenario of different development.

6. ROLE OF MUTATION IN PLANT BREEDING

The main strategy of mutation-based plant breeding is to upgrade the well-adapted varieties by altering one or two major traits. Several characters such as plant height, seed dehiscence, and disease resistance are upgraded which increases yield and quality traits such as oil profile content, malting quality, and the quality and size of the starch granule. Grain yield of barley, rice, wheat, and maize increased due to the resistance to lodging and high-density planting. Induced mutation offers more prospects for the improvement of self-fertilizing species than cross-fertilizing species. This is generally due to two reasons. Difficulty in selecting, incorporating, and maintaining recessive mutations in such population is one and the plant breeding problems in cross-fertilizing species which are more often problem of handling the existing variability than lack of variability per sec is another problem. Though, variability induced by mutagens utilized several successful plant improvement ventures. (Botany et al., 1971)

6.1 INVITRO and MUTAGENESIS

The availability of large populations for mutations is one of the basic prerequisites for obtaining adequate variability. Mutation techniques increase the power of clonal propagating plants such as bananas, bananas, apples, pineapples, date palms, potatoes, sweet potatoes, cassava, carnations, chrysanthemums, roses and tulips with tissue culture and molecular methods. Almost all of these plants can reproduce and reproduce in vitro, which allows them to produce large populations in a small space and in a short time. In vitro breeding date palm, apple, potato, sweet potato and pineapple radiation now offers a way to treat large populations, which was not possible before. Provides a miniature version of the trees and seeds in the petri dish to replace the irradiated field of microscopic plants, mold and adventure buds, apical meristems, regenerating callus cultures, pollen and microspores and somatic nuclei.

6.2 Developmental Mutant

Arabidopsis Thaliana, maize, barley, pea and tobacco-induced mutation in genes is used to isolate and identify genes that regulate plant growth, especially at the beginning of flowering, flower bud formation, seed and fruit formation, and fruit ripening. These mutants include growth regulators (phytohormones) such as auxins, cytokinins, gibberellins, aphthous acid, ethylene and brassinosteroids (Wilde, 2016). In the development of many grains such as wheat, rice, corn and barley, dwarf mutants (natural or induced) have played a key role in producing varieties that are resistant to lodging-resistant and highly fertilizer responsive. Arabidopsis mutant etr1, which provides ethylene synthesis and sensitivity, is of major value in increasing the shelf-life of fruits and the late maturation shown by conversion to tomato and petunia. Many mutants, such as ein, ain and NR (never ripened) in Arabidopsis, have a severely limited or weak response to ethylene. Such mutants play an important role in the international trade of fruits such as papaya, pineapple, mango, and banana, and cut flowers, which spoil quickly after ripening.

6.3 Mutants for changing starch quality

Starch is the main carbohydrate substance stored in the amyloblasts of seeds and tubers, and is the main source of energy in the human diet. Rice, wheat, corn, corn, oats, barley, cassava, potatoes, sweet potatoes, bananas and plantains: High in starch. Starch can be classified into two types of macromolecules, amylose and amylopectin. Mutations affecting the biology of starch can dramatically change the size of both components, resulting in changes in the physio-chemical properties of starch particles.

6.4 Mutation and genetic engineering

As part of modern biotechnology, the in-vitro culture of plants is also undergoing rapid development. These techniques now offer many advances for mutation reproduction as well. They may accelerate mutation reproduction due to the rapid clonal proliferation of interesting mutants for further evaluation (Botany et al., 1971). Such "micro-diffusion" techniques are already well-established for many organisms, using apical shoot tips, meristems, various interpretations or cell suspensions. As a result of the rapid development of technological skills, plant breeders can be expected to focus more on individual gene manipulation, gene nutrition, and gene reproduction, not only in the cell nucleus also in the cytoplasm. Therefore, it is no exaggeration to say that nutrient reproduction begins to play an important role in plant reproduction.

Azolla variants are tolerant of high salinity, toxic aluminum levels, and /or herbicide due to mutation breeding. Germplasm preservation and clonal material exchange at the international level are done in yam, potato, and sweet potato. Somatic embryogenesis and regeneration in Musa are identified as tolerant of Panama disease on screening (Novak, 1992).

7. FUTURE PROSPECTS

Mutations are used in crop improvement through two sets of technologies, in vitro culture and molecular method. Induced mutations are not only limited to crop improvement but also used in exploring biology (Brunner,

1995). After 50 years of progress, we find ourselves still dependent on the use of mutants for understanding physiology and regulation of mutation for balancing genomic stability with plasticity and for probing biological processes.

8. MUTATION BREEDING

8.1 Advantages

Mutation breeding shortens the time taken for the development of cultivars via induced mutation compared to those via hybridizations and also creates variability in a crop species (Toker et al., 2007). but also The average time elapsed from initial mutation treatment to the release of the mutant cultivars was approximately 9 years while this time was more than 9 years for cultivar arising from crossing programmes. Furthermore, mutations induced both qualitative and quantitative characters in a short time altering new alleles of known and previously unknown genes, and modify linkage.

9. CONCLUSION

If the breeder knows certain possibilities and limitations, it will guide to make the right use of this tool. One of the most important approaches of induced mutagen is to widen the genetic variation and diversity in crops. It is essential, provable, robust, transferable, and environmentally friendly. The exploitation of mutation breeding develops crop varieties which give a contribution to improved crop varieties and nutritional security. The ultimate aim of mutation induction is to direct the procedures yielding the highest possible number of desirable mutations which are to be used in plant breeding and its functions. A concept of optimum mutation frequency is to replace the concept of maximum mutation rate and a reorientation towards an objective specific dose. Concept must go along with improved methods of selection. There is no longer a need to prove that radiation can provide useful genetic variation for crop improvement. Induced mutation is expected to play a crucial role for crop improvement and improving livelihood in future an even greater role for the success of plant breeding.

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