

CHAPTER-5

ROLE OF MUTATION BREEDING IN CHICKPEA IMPROVEMENT: A MINI REVIEW

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Summary

Mutation refers to any heritable changes in an individual's genome or phenotype. Mutation breeding is the most powerful and effective technique in the hands of plant breeders. It has been utilized to improve morphological and physiological characteristics, disease resistance, drought resistance, and quantitative traits such as yielding ability. It is a low-cost and rapid approach of creating new improved crop cultivars. Plant breeding focuses on the genetic diversity in essential traits in order to create new, high-yielding, and better cultivars with desired traits. The seeds of chickpeas are the cheapest protein source and have the potential to reduce food scarcity and quality issues. The development of novel high producing and qualitative food is a difficult task for crop breeders, but it can be accomplished through mutational breeding techniques. The present article is focused on the in depth insights as a role of mutation breeding in chickpea improvement

Keyword: Mutation, Phenotype, Breeding, Chickpea, Improvement.

Introduction

Hugo de Vries introduced the term mutation in 1901. Mutation is described as a permanent and infrequent change in the number or sequence of nucleotides. Mutation breeding is the process of genetically improving crop plants for various economic characteristics via induced mutations.

Mutations have been induced by physical mutagens such as X-rays, gamma rays, fast and thermal neutrons, heavy ion beams, and chemicals such as EMS, DES, and SA. According to the current situation, 408 mutant varieties of food

legume crops belonging to 24 different crop species have been released for production globally utilizing mutation techniques. (Kharkwal et al., 2005). There is enormous potential to improve the mineral nutrient (biofortification) and essential amino acid content of human and animal feed, as well as the protein and fatty acid profiles, physicochemical properties of starch, phytonutrients in fruits, and reduced antinutritional factors in staple foods. Induced mutations may play an essential role in producing mutations that improve nutritional quality in crop plants. Approximately 3,000 mutant crop varieties are generated globally, with 776 identified for their better nutritional qualities (Jain et al., 2010).

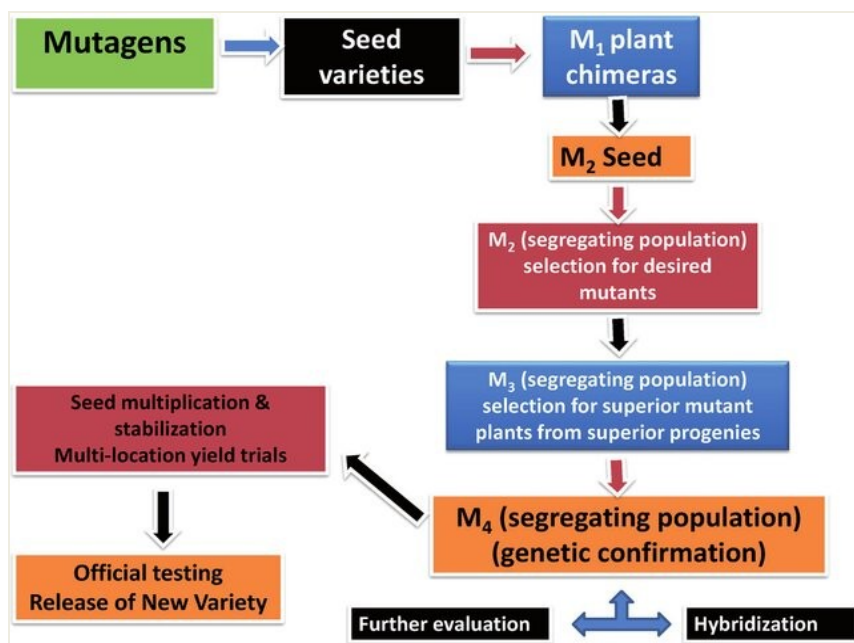


Fig.1. Scheme of mutation breeding in crop plants; Source-Arain et.al. 2020

Chickpea (*Cicer arietinum* L.)

Chickpea is a high-protein food, and India is the world's leading producer, accounting for up to 65% of global output. Over 100 chickpea cultivars have been released across the country. Mutation breeding developed five high-yielding varieties: Kiran, Ajay, Atul, Girnar, and BGM-547 (Table 1). Creating diversity is a constant process of improvement and mutation is an effective method for generating variability. Numerous studies in chickpea have been conducted to investigate the mutagenic effect of various mutagens in order to create mutants with increased yield potential and other beneficial characteristics (Solanki et. al. 2011).

Previous research findings show that EMS is more successful in causing mutations in the little seeded variety and gamma rays in the bold seeded type (Pathania and Sood, 2006). EMS produces more morphological mutants such as dwarf, compact, prostrate, gigas, white flower, non-flowering, and sterile than HZ (hydrazine hydrate) or SA. EMS and gamma radiation cause significant chlorophyll modifications (Barshile et. al., 2006). Glabrous mutants have been identified in the EMS mutant progeny, both EMS and gamma rays have the potential to generate mutants with larger and more seeds. (Wani and Anis, 2008). HZ is proven to be effective, followed by SA and EMS, in terms of seedling damage, pollen sterility, and meiotic abnormalities (Khan et. al., 2005). The mutation does depend on the type of mutant, its dose, and the genotype mutated. The introgression lines of desi x kabuli genotype are shown to be most resistant to mutagenic treatments, followed by desi types and kabuli types (Shah, 2008). The EMS creates mutants with compact growth, erect growth habits, thick and strong stems, short internodal and interleaflet intervals, and few tertiary and later order branches, which may be valuable in ideotype breeding. (Guar et. al, 2008).

In chickpea, the range of mutations affecting important genes was found to be high with NMU as compared to EMS, and gamma ray mutants developed were miniature, dwarf, compact, and upright types, fitting the ideotypes that are essential in chickpea varietal development. (Kharkwal, 2000). Gamma rays have been discovered to be useful in the production of disease resistant varieties, such as CM 98, against *Ascochyta* blight and wilt (Haq et. al., 1999). In terms of quality metrics, mutation treatments with gamma rays improve the degree of softness of seed, hence improving cooking quality (Graham et. al., 2002). The work on mutation began many years ago, but the first mutation-based variety, 'CM 72', was launched in Pakistan in 1983 and was proven to be resistant to '*Ascochyta* blight'. It resulted from the radiation treatment of local cultivars, followed by disease resistance selection in segregating mutant populations. In 1984, the first Indian mutant variety, 'Kiran' (RSG-2), was released, followed by Ajay, Atul, and Girnar in 1985. After a lengthy wait, 'BGM-547' was launched in 2005. It is high yielding and resistant to wilt and root rot complexes.

Four gigas mutant plant types were identified from the M2 population of Chickpea cultivar Vijay; three were treated with 300 Grey and one with 0.2% EMS. All gigas have a dominating phenotypic appearance, 1.5 times taller than the control, with an elongated, rigid stem and wider, broader leaflets. The EMS gigas has fewer primary branches and smoother bigger leaves. One of the 300 Grey treatments was sterile, while the remaining three contained flowers and pods. One gigas (EMS 0.2%) demonstrated 10 days early flowering compared to the control (Bogawar et. al. 2017).

The seeds of three desi varieties of chickpea released from Pantnagar were mutagenized using physical mutagen (gamma rays at 300 and 400 Gy doses) and chemical mutagen (ethyl-methane sulphonate 0.5%), as well as combinations of the two. M₁ generation exhibited a constant decrease in germination with

increasing mutagen strength. Furthermore, combination treatments induced more biological damage than single mutagen treatments. In M2 generation, variability for varieties revealed notable differences in thirteen agronomic traits, with the exception of two: the number of primary branches per plant and pod length. However, every type of mutagenic treatments and variety x treatment variation were significant for eight variables such as yield per plant (Dinkar et. al., 2020).

The number of secondary branches of Chickpea grew dramatically in two treatments: 300 Gy alone and in conjunction with 0.5 EMS. The genotypic response differed depending on the mutagenic amount for distinct characteristics. Although none of the genotypes responded considerably better than the control for yield per plant at any of the treatment levels, one genotype, PG114, showed significant increase in yield component trait pods per plant at 300 Gy + 0.5% EMS level (Dinkar et. al., 2020). EMS was found to be more effective than gamma rays and combination treatments in causing mutations. Among the two varieties of chickpea, the response to mutagenic effectiveness was greater in the var. pusa-372 than in the var. pusa-212 (Wani, 2009).

Table 1: Chickpea varieties developed through mutation breeding

Name of variety	Year of release	Centre of research	Parent variety	Mutagenic agent	Varietal Characteristics
Kiran (RSG-2)	1984	ARS Durgapura, Jaipur	RS-10	Fast neutrons	High pod number, early, high yielding with salinity tolerance
Ajay (Pusa-408)	1985	IARI, New Delhi	G-130	60 kR γ -rays	High yielding with 140-150 days maturity
Atul (Pusa-413)	1985	IARI, New Delhi	G-130	60 kR γ -rays	High yielding, Wilt resistant, 130-140 days maturity
Girnar (Pusa-417)	1985	IARI, New Delhi	BG-203	60 kR, γ -rays	High yielding, wilt resistant, semi erect, dwarf, 110-130 days maturity
BGM-547	2005	IARI, New Delhi	BG-256	300 Gy	High yielder, mature within 135 days and tolerant to wilt, root rot and stunt diseases

Source: Solanki et. al. 2011.

Applications of mutation breeding

Mutation breeding can create a great deal of variability in a crop species, which can then be used to improve germplasm and develop new cultivars. Another significant advantage of mutation breeding over hybridization is the time required to develop a new variety. Generally, 11-12 years are required to develop a new variety via hybridization, while it takes only 8-9 years by using method of mutation breeding (Brock, 1977). Mutations may produce both qualitative and quantitative variations in a shorter time by affecting alleles at known loci as well as recently identified loci, in addition to changing linkage groups (Konzak et al. 1977). Mutations in Leguminosae can create new variability for many beneficial features, whereas variability is limited to the parents used in hybridization. Mutagenesis can produce any type of variation found in any plant family's germplasm if the gene is present in the treated plant (Toker 2004).

Future Prospects of mutation breeding

Pulse genomic research is gaining progress in the biotechnology era that has begun with cereals. In the near future, we will require saturated genetic maps and researched genomics knowledge. Mutants are required for investigating gene expression and regulation. Although some plant genomes have been sequenced, many DNA sequences can only be assigned functions through induced mutation with gamma rays, fast neutrons, or chemical mutagens (Ahloowalia 2001). Mutants that were formerly discarded by investigators as having little reproductive value are now becoming a significant tool in genome study. Damage to the DNA of a specific gene sequence is now possible in pooled samples acquired from vast mutant populations utilizing a revolutionary mutation detection technique.

This method, which is becoming more and more popular these days, is called "targets included local lesions in genomes" or "TILLING" (McCallum et al., 2000a). TILLING can be used effectively. It is difficult to choose the appropriate genotype from a population that has variance produced by any method. Molecular probes have made it possible to choose the identified mutations. Future efforts to improve pulses will focus more on developing molecular markers and sequencing the altered genes. Mutation breeding and marker-assisted selection can be used to create cultivars that are more efficient at absorbing micronutrients, more resilient to biotic pressures like disease and insect pests, and more tolerant of abiotic challenges like drought, cold, and salinity.

Conclusion

Growing human populations, a shortage of cultivable land, and fluctuating climatic patterns create a danger to the sustainability of global agriculture. One important way to solve these issues and create unique germplasm quickly is through plant mutation breeding. One breeding technique used to enhance crop

plants for human benefit is mutation breeding. To improve crop plants, many mutant breeding techniques were employed.

To date, physical mutagenesis has been employed in conjunction with electromagnetic radiation, including gamma, X, and UV rays, as well as particle radiation, including thermal and fast neutrons, beta, and alpha particles. Radiation was the most often utilized mutagen in crop improvement among the physical mutagenesis techniques. Chemical mutagens such as diethyl sulphate (DES), sodium azide (NaN₃) treatment of seeds, and ethyl methane sulfonate (EMS) were also employed to improve agricultural crops. Chemical mutagens are frequently employed to increase genetic variety in higher plants since it is a necessary feature of successful breeding programs in plants that are propagated both vegetatively and sexually.

By producing several mutants in various crop plants, induced mutagenesis has played a significant role. Due to their unique characteristics, such as high yield and resilience to biotic and abiotic stressors, these mutant cultivars have been cultivated all over the world, improving livelihoods and contributing to global food and nutritional security.

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