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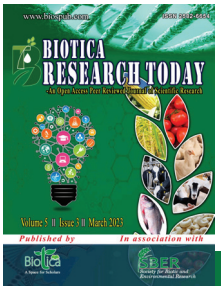

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Mutation Breeding: An Efficient Approach of Generating Genetic Variability and Developing New Variety in Sunflower (*Helianthus annuus* L.)

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Abstract

Mutation breeding is one of the fasted and efficient methods of generating genetic variability in crop plants. Several mutagens including chemical mutagens like EMS and physical mutagens like gamma radiation, fast neutrons, ultrasounds *etc*., have been frequently used in generation of mutant lines in crop plants. In sunflower also, mutation breeding has been successfully utilized not only in generating mutant lines but also has led to the development of mutant sunflower varieties which has been enlisted in mutant variety database (MVD). Along with phenotypic traits like plant height, number of seeds, seed weight, seed size, head diameter *etc*., the oil quantity and qualities can also be enhanced through mutation breeding. Therefore mutation breeding can be effectively utilized in sunflower as well as other crop improvement programmes.

Keywords: Ectendomycorrhizae, Ectomycorrhizae, Endomycorrhizae, Mycorrhizae

Introduction

Sunflower (*Helianthus annuus* L.), an annual diploid (2n=34) crop species is an important oilseed crops of the world including India. It belongs to the Asteraceae family and reported genome size is around 3.5 GB. Sunflower products and by-products are used in a variety of industries, including animal feed, paper, snacks and confectionary. Sunflower flowers have nectar and pollen, which can be used to make honey. Sunflower is cultivated more than 70 countries in around 25 Mha area with a world average productivity of 1,637 kg ha^{-1}. Global sunflower seed production was 47.20 million tonnes during 2017-18. The Russian Federation, Ukraine and Argentina are the main producers of sunflower seed, its by-products and suppliers to the global market. Russia and Ukraine have the highest percentage portion in the sunflower production. Russia and Ukraine produces sunflower around 50% out of total production in the world. Countries such as China, Bulgaria, Turkey and France have higher productivity with an average yield higher than 2.0 t ha^{-1} as against lower than 1.0 t ha^{-1} in India (Ministry of Agriculture & Farmer's Welfare, GOI, 2018). All India total production of sunflower was 9 lakh tonnes in 2018. All India average yield of sunflower was 590 kg ha^{-1} and Haryana state has the highest yield 2,000 kg ha^{-1} in 2018 (Ministry of Agriculture & Farmer's Welfare, GOI, 2018). However, the production of sunflower seeds for oil in India is not at all sufficient to meet the domestic demand of sunflower oil, thus largely depends on imports of huge quantity of sunflower oils from other countries. The cultivation of sunflower is hampered by several constraints, which includes diseases and insect pest infestation, sowing time overlap with other major crops like maize, wheat potato *etc*., low yield in many states of India, in-sufficient activity of the bee in the sunflower growing areas during flowering. Therefore, it is an inevitable step to develop sunflower varieties/ hybrids which will overcome the aforementioned constraints and have wider acceptance by the farmers. As a basic necessity in plant breeding programmes, a crop plants with wide genetic diversity possess a higher potential of genetic improvement through crossing and other similar techniques

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where the breeders brings all the desirable traits in single genotypes through various plant breeding techniques which are nowadays effectively aided by biotechnological tools.

Mutation Breeding of Sunflower

In any mutation breeding programme of crop plants, the main objective is to generate new genetic variations could become a potential source of genetic improvement in crop plants as well as for the crop plants evolution towards desirable traits. The segregating generations of mutant lines provides large numbers of variations for different traits on which phenotypic evaluation is performed under field condition to evaluate the performance of each mutant line under specific agro-climatic conditions and also to evaluate the performance of mutant lines for desirable traits. Such phenotypically evaluated and selected lines could be used for breeding programmes of crop plants including sunflower. Over other techniques, mutation breeding has certain advantages such as it is a quick method of generating genetic variability, it is robust method, cost effective, environment friendly and in most of the cases it is non-hazardous (Laskar *et al.*, 2018). Moreover, phenotypically superior mutant lines which are identified through field evaluation could be released as a new variety which is supported by the fact that more than 3,365 mutant varieties of more than 210 crop plant species have been released for commercial use and are enlisted in Food and Agriculture Organization of the United Nations/ International Atomic Energy Agency - Mutant Variety Database. Similarly, in sunflower also, several mutant varieties have been released till date which is enlisted in MVD (MVD, 2022) (Table 1).

The evaluation of mutant lines will help in identification of lines possessing different desirable characters like resistance to biotic and abiotic stresses, short duration, autogamy, more number of seeds head^{-1}, larger head diameter, higher oil content, dwarf height *etc*. From the large population of mutant lines, desirable mutant line(s) can be identified. The identified mutant lines for different desirable traits can be used in sunflower improvement breeding program. Also, the mutant lines with better yield performance can be released as new mutant variety.

Use of Gamma Irradiation to Generate Mutant Lines of Sunflower

Among the several mutagens or induce mutation techniques that are reported, gamma irradiation is one of the best method. Several recent literatures also highlights about the application of gamma irradiation to generate mutant lines of sunflower to enhance different desirable traits such as increased oil content, increased germination %, reduced plant height, increased number of seeds head^{-1}, seed fresh weight. Similarly, we have also conducted experiment with gamma irradiation of sunflower seeds (Figure 1) and reported the significant phenotypic variations in yield and yield attributing traits along with enhanced oil quality in terms of antioxidant activity (Rajeev *et al.*, 2022).

Table 1: Mutant varieties of sunflower that are enlisted in Mutant Variety Database (Source: FAO/IAEA-MVD)

Mutant Variety	Country	Descriptions
Pervenetch	Russia	Released year: 1977; Mutagen: 0.05% DMS; Properties: high oil content (67.4-75.4%) with altered fatty acid composition.
Jingkui1	China	Released year: 1987; Mutagen: fast neutrons ($5\times10e^{10}$); Properties: improved plant structure and altered maturity.
RADA	Bulgaria	Released year: 2006; Mutagen: gamma rays; Properties: hybrid variety; the restorer line is a mutant, resistance to diseases.
TAS-82	India	Released year: 2007; Mutagen: gamma rays; Properties: tolerance to drought and black seed coat.
Madan	Bulgaria	Released year: 2008; Mutagen: gamma ray; Properties: The female parent in the cross was the mutant line 6127, large seeds, improved oil and protein content.
YANA	Bulgaria	Released year: 2009; Mutagen: ultrasound waves; Properties: the male parent was mutant, high oil content and large number of seeds head^{-1}.

Figure 1: Screening of mutant sunflower lines at RPCAU, Pusa derived through gamma irradiation of sunflower seeds

Conclusion

The mutation breeding is one of the well established and an efficient method of generating genetic variability in crop plants in a short period of time. Among many other crops, mutation breeding has been extensively utilized in sunflower also and several varieties of sunflower have been released with altered qualitative as well as quantitative traits. Among the mutagens, EMS is frequently used as chemical mutagens and in physical mutagen, gamma radiation is frequently used

to induce mutation in crop plants including sunflower. From the large segregating mutant lines, the mutant line with desirable traits are selected which ultimately provide the genetic sources of desirable traits in crop improvement and it can also be directly released as new variety if it performs superior than other existing varieties.

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