AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly e Newsletter
Volume 1 – Issue 1
www.agriallis.com

MUTATION AND IRRADIATION: IMPORTANCE IN THE FIELD OF AGRICULTURE

Article Id: AL201908

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Mutation is defined as the sudden heritable change to an individual's genetic makeup, which results in new traits that are passed on from parent to offspring and thereby, leads to evolution. In nature, mutations are caused by errors in the replication of deoxyribonucleic acid (DNA).

Muller, 1927 demonstrated radiation caused mutations in fruit flies and in the crop plants maize and barley by Stadler, 1928 which followed the discoveries of X-rays by Roentgen in 1895; radioactivity by Becquerel in 1896; and radioactive elements by Marie and Pierre Curie in 1898. The subsequent rapid and widespread adoption of induced mutations as a crop improvement tool derives directly from these pioneering discoveries.

The plant materials are exposed to radioactive particle or chemical compound in mutation breeding experiments, which may change the genetic constitution of plants. The physical mutagens are comprised of ionized radiation viz., particulate (alpha radiation and Beta Radiation). Ionizing radiations such as X-rays and γ-rays are more preferred over any other mutagens because of their ease of application, good penetration and reproducibility, high mutation frequency and less disposal problems. During the last two decades, the use of ion beam irradiation has emerged as an effective and unique technique for inducing mutations in plants (Tanaka *et al*. 2010).

Mutation may be used to obtain superior mutant for different traits like high yield, drought tolerance, disease resistance, quality, color, taste etc. The efficiency of mutation breeding is dependent on the effectiveness with which useful variants can be recognized in M2 or M3 generation. The first step in the mutation breeding selection process is to reduce the population of potential variants to a sufficiently small fraction to permit more detailed

analysis and evaluation. In order to determine the optimal dose of gamma irradiation, subsequent growth rate is recorded from the treated population. The plantlet height is used to determine optimal dosage for mutation induction as growth reduction GR_{30} and GR_{50}. Determination of LD_{50}value helps to define exact mutation dose (Predieri, 2001). The plants sensitivity to irradiation varies according to species, cultivar and the plant's physiological conditions (Britt,1996)

Applications of irradiation in agriculture

Crop improvement

Plant breeding requires genetic variation of useful traits for crop improvement. Different types of radiation can be used to induce mutations to develop desired mutants' line that are resistant to disease, are of higher quality, allow earlier ripening, and produce a higher yield. American Scientist L.J. Stadler in 1930 using X-rays induced mutations in plants. Later gamma and neutron radiation were employed as ionizing radiations. This technique of utilizing radiation energy for inducing mutation in plants has been widely used to obtain desired or improved characters in number of plant varieties. It offers thepossibility of inducing desired characters that either cannot be found in nature or have been lost during evolution. A proper selection of mutant varieties can lead to improved quality and productivity.

Bhabha Atomic Research Centre (BARC) has developed number of high yielding varieties of green gram, black gram, groundnut, jute and rice by using radiation energy for inducing mutation (Sood *et al*., 2010).

Plant nutrition studies

Fertilizers are very expensive and their efficient use is of great importance to reduce the production cost of agricultural crops. It is essential that a maximum amount of fertilizer used during cultivation finds its way into the plant and that the minimum is lost. Radioisotopes are very useful in estimating the amount of phosphorus and nitrogen available in the soil. This estimation helps in determining the amount of phosphate and nitrogen fertilizers that should be applied to soil. Fertilizers labelled with radioactive isotopes such as phosphorus-32 and nitrogen-15 have been used to study the uptake, retention and utilization of fertilizers. Excessive use of fertilizers effects biodiversity and damages the environment.

These isotopes provide a means to determine about amount of fertilizer taken and lost to the environment by the plant (Harderson, 1990).

Insect pest management

Insect pests are responsible for significant reduction in production of agricultural crops throughout the world (Alphey, 2007). They not only reduce crop yields but also transmit disease to cultivated crops. Radiolabel pesticides were used to monitor the persistence of their residues in food items, soil, ground water and environment. These studies have helped to trace and minimize the side effects of pesticides and insecticides. There are concerns that continuous uses of pesticides have negative impacts on the environment and it also results into development of resistance against pesticides in many insect species (ANBP, 2005).

IAEA is using nuclear science to develop environmentally friendly alternatives for pest control. FAO and IAEA division jointly sponsors projects and conducts research on control of insects using ionizing radiations. They have placed considerable emphasis on the Sterile Insect Technique (SIT) proposed by Knipling in 1955. This technique relies on application of ionizing radiation as a means to effectively sterilize male insects without affecting their ability to function in the field and successfully mate with wild female insects. This technique involves release of large numbers of sterile male insects of the target species in the field crop. Sterile male insects compete with the regular male population during sexual reproduction and the eggs produced from their mating are infertile so they produce no offspring(Morrison *et al*., 2010). It is highly specific form of "birth control which reduces and eliminates the insect population after two or three generations. It has been effectively utilized in elimination of Mediterranean fruit fly from US, Mexico and Chile and screw worm infestation in the US and Mexico (Klassen and Curtis, 2005). It has been successfully used to eradicate several insect pests of agricultural significance throughout the world.

Conclusion

Radiations can be applied in a number of ways to solve many problems in the agriculture and allow the industry to be more efficient. These applications are especially important for developing nations or areas where resources are scarce and for preserving natural resources while meeting the challenges of food security.

References

Alphey, L. (2007). Engineering insects for the Sterile Insect Technique. In Area-wide control of insect pests: from research to field implementation, M. Vreysen, A. Robinson, and J. Hendrichs, eds. (*Dordrecht, The Netherlands, Springer*), pp. 51-60.

ANBP (Association of Natural Biocontrol Producers) (2005). http://www.anbp.org/

Britt A. B, (1996). DNA Damage and Repair in Plants, *Annual Reviews Plant Physiology*, 47, p. 75-100.

Klassen, W., and Curtis, C.F. (2005). History of the sterile insect technique. In Sterile Insect Technique Principles and practice in area-wide integrated pest management, V.A. Dyck, J. Hendrichs, and A.S. Robinson, eds. (*The Netherlands, Springer*), pp. 3-36.

Morrison, N.I. Franz, G., Koukidou, M., Miller, T.A., Saccone, G., Alphey, L.S., Beech, C.J., Nagaraju, J., Simmons, G.S. andPolito, L.C. (2010) Genetic Improvements to the Sterile Insect Technique for Agricultural Pests Asia Pacific J. *Mol. Biol. Biotechnol*. 18 (2): 275-295.

Predieri, S. (2001). Mutation Induction and Tissue Culture in Improving Fruits, Plant Cell, *Tissue and Organ Culture*, 64, p: 185–210.

Sood, D.D., Reddy, A.V.R. and Ramamoorthy, N. (2010) Applications of radioisotopes in agriculture and Industry. In Fundamentals of Radiochemistry, IANCAS (4th Eds), Perfect Prints, India, pp 296-310.

Harderson, G. (1990). Use of nuclear Techniques in Soil Plant Relationships, Training Course Series No. 2, IAEA, Vienna.

Yamaguchi, H, Nagatomi, S, Morishita, T, Degi, K, Tanaka, A, Shikazono, N, andHase, Y. (2003). Mutation induced with ion beam irradiation in rose.*Nuclear Instruments and Methods in Physics Research*.206 (4): 561-564.