JUST AGRICULTURE
multidisciplinary e-Newsletter

Terminator Seed Technology

Vedant sachan[1] & Shama parveen[2]
Research Scholar, Deptt. of Genetics & Plant Breeding, School of Agriculture, ITM University, Gwalior
Associate Professor, Deptt. of Genetics & Plant Breeding, School of Agriculture, ITM University, Gwalior.

ARTICLE ID: 92

Introduction

It is the method for restricting the use of genetically modified crops by activating some genes only in response to some stimuli, especially to cause second generation seeds to be infertile, this method is known as "Genetic Use Restriction Technology (GURT)" also known as "Terminator technology "and the seeds produced are known as "Suicide seeds".

It was developed by the multinational seed and agrochemical industries and introduced by the U.S. government to prevent farmers from re-planting harvested seed and force farmers to buy new seeds each season& to prevent useful transgenes from being pirated.

Testing and commercialization of "Terminator" seed is banned by the government of India. Any seed imported into or registered in India requires to be without "Terminator technology", this is done to facilitate the farmers in India.

TPS (technology protection system) or Suicide technology

There are three gene's crucial for the working of TPS.

i) Cre- recombinase gene
ii) Repressor gene
iii) Terminator gene (ribosomal inactivating protein gene)

Types of GURT's used in developing plant varieties:

1. **V- GURT (varietal)**: Targets the reproductive process, produces sterile seed, typically it involves chemical induction of a disruptor gene or chemical suppression of a constitutively active disrupter gene. Plants treated with a chemical inducer fail to produce viable seed, or the absence of the suppressor chemical would produce sterile seed. Examples from classical breeding includes seedless watermelon or seedless grapes.

JUST AGRICULTURE
multidisciplinary e-Newsletter

2. **T- GURT (trait):** Is an inducible promoter, often termed "Gene switch" that regulates the turning "on" or "off" of gene of interest, can also be used for removal of inserted genes not critical for expression of the desired trait, such as selectable marker genes. It does not affect plant fertility, example from classical breeding includes hybrid corn, where the crop does not breed true, but does produce viable seed.

Application in crop improvement

Genetic use restriction technologies (GURTs), developed to secure return on investments through protection of plant varieties, are among the most controversial and opposed genetic engineering biotechnologies (Lombardo, 2014). GURT may be variety specific (Terminator technology) or trait specific (Traitor Technology). Traitor technology is the second generation of terminator technology with similar or near to similar mode of action (Fisher, 2002). Terminator technology on one side controls the plant fertility and the Traitor technology on the other side is designed to switch on or off of a trait, however, without killing the embryo (FAO, 2001). The genetic modification is activated by a chemical treatment or by environmental factors. The main version of the terminator includes a set of three novel genes which are inserted into one plant. However, there is another version, which divides two or three genes on to two plants that are later to be cross-pollinated (Oliver and Velten, 2001; Gupta 1998). The ultimate outcome is a sterile seed in the following generation. The disrupter protein may or may not be permanently active in the seed depending on the mechanism involved in V-GURT (Lombardo, 2014).

Recoverable block of function uses the barnase and barstar genes for gene flow control in transgenic plants (Kuvshinov et al., 2001). The terminator technology Patented by Syngenta in 2001 has its implication in the vegetatively reproducing crops to increase the shelf life of the commodity during storage. Technology for selective termination of the transgenics has been developed by use of RNA interference (Lin et al., 2008). Repressible Seed Lethal System (Schernthaner et al., 2003) is a strategy based on the simultaneous insertion at the same locus on homologous chromosomes of a seed lethal gene linked to a novel trait (SL-NT) and a repressor gene (R). It ensures sterility of the seed carrying the novel trait formed by outcrossing. T-GURT or Traitor technology may work on excision of the gene of interest (transgene) or by transfer of the transgene to subsequent generation in inactive form (Shi, 2006). The former mechanism (Zeneca patent) leads to second generation

JUST AGRICULTURE
multidisciplinary e-Newsletter

plant without the trait under consideration. The trait can be activated in the latter mechanism by application of specific chemical inducer. GM-gene-deletor system is a strategy developed to remove all functional transgenes between two recognition sequences from pollen, seeds, fruits and other edible parts of GM crops (Luo et al., 2007).

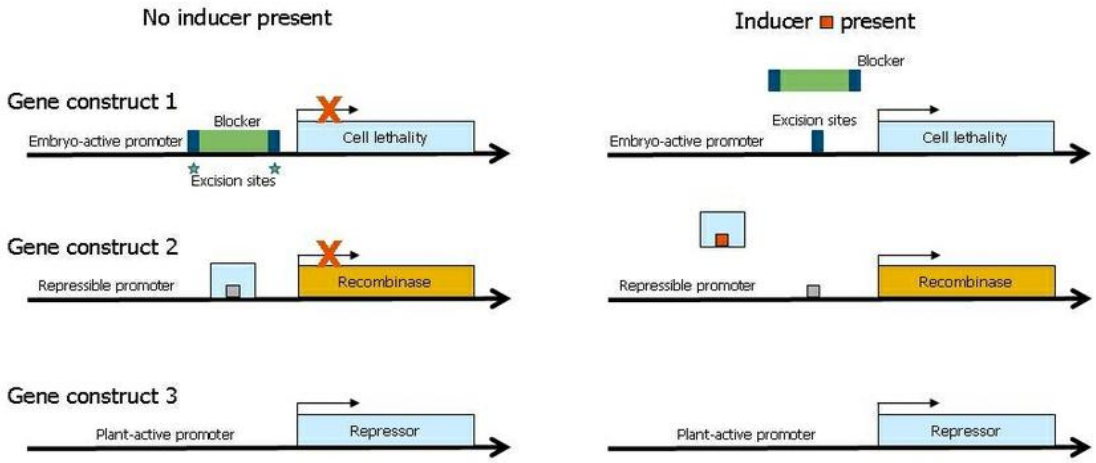

Figure 1. Mechanism of action of terminator gene after treating with inducer (tetracycline).

Potential benefits for crop improvement& farmer's

1. Avoid transfer of characteristics from genetically improved crops to other varieties.
2. Express the gene of interest which are needed.
3. A potential technical tool for added protection of biodiversity by minimizing or potentially eliminating dissemination of viable seed into the environment improving containment and protecting biodiversity.
4. A tool that protects intellectual property, which encourages investment and innovation.
5. As farmers will use new seeds every year it will directly lead to good production.
6. Competition between private and public sector institutions will lead to the benefit for farmers.

Related Concern's

1. It creates the potential loss of farmer's ability to save seed.
2. GURTs could escape into wild populations, with negative environmental impacts.
3. Impact on public receptivity to agricultural biotechnology.

JUST AGRICULTURE
multidisciplinary e-Newsletter

4. If the seeds are used for food purpose it may cause health related issues due to the treatment of seeds with chemicals.
5. Only rich farmers will be able to do the cultivation of crops with "Terminator technology", small farmers will not be able to afford.
6. It may have negative impact on employment and on consumers also.

Conclusion

It is very difficult to predict the development of GURTs in the near future because they seem still out of the way from commercialization. T-GURTs could be received by public belief as a favourable innovation as they would allow farmers to switch on desirable valuable trait. T-GURTs would not hinder plant viability and would not affect the traditional conservation practices and exchange of seeds, offering at the same time a solution to the problem of genetic pollution by avoiding the spread of the engineered traits.

The research is majorly focused to benefit the private sector companies but in country like India where farmers are dependent on government for good policies to improve farming practices and quality of crop production by the help of government research centers, the research must be more focused to help the farmers.

References

FAO, 2001. Potential Impacts of Genetic Use Restriction Technologies (GURTs) on Agricultural Biodiversity and Agricultural Production Systems. Wageningen University Research Centre. The Netherlands.

Kalundrekar, S.P.,Singh, P.K., 2021. Terminator Gene Technology and its Application in Crop Improvement. Natural Resource Management and Sustainable Food Production (ISBN: 978-8188805-150). pp.216-226.

Kuvshinov, V., Koivu, K., Kanerva, A., Pehu, E., 2001. Molecular control of transgene escapes from genetically modified plants. Plant Sci. 160, 517-522.

Lombardo, L., 2014. Genetic use restriction technologies: A review. Plant Biotechnol. J. 12, 995-1005.

Luo, K., Duan, H., Zhao, D., Zheng, X., Deng, W., Chen, Y., Stewart, C.N.Jr., McAvoy, R., Jiang, X., Wu, Y., He, A., Pei, Y., Li, Y., 2007. GM-gene-deletor: fused lox P-FRT recognition sequences dramatically improve the efficiency of FLP or CRE

recombinase on transgene excision from pollen and seed of tobacco plants. Plant Biotechnol. J. 5, 263-274.

Malav, A.K., Gaur A., 2017. Terminator Gene Technology and Its Application in Crop Improvement.Int. J. Curr. Res. Biosci. Plant Biol. 4(5), 57-60.

Oliver, M.J., Velten, J., 2001. Development of a genetically based seed technology protection system. In: Dealing with Genetically Modified Crops (Eds.: Wilson, R.F., Hou, C.T., Hildebrand, D.F.). AOCS Press, Champaign, IL. pp.110-114.

Schernthaner, J. P., Fabijanski, S.F., Arnison, P.G., Racicot, M., Robert, L.S., 2003. Control of seed germination in transgenic plants based on the segregation of a two-component genetic system. Proc. Nat. Acad. Sci. (USA). 100, 6855-6859.

Shi, G., 2006. Intellectual Property Rights, Genetic Use Restriction Technologies (GURTs), and Strategic Behavior. American Agricultural Economics Association Annual Meeting. Long Beach, California.