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Plant Genetic engineering: a better tool than conventional breeding

Loveleen Arora[1] and Anand Kumar[2]

[1,2] Department of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Sirhind-140406 (Punjab)

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Abstract:

Since years, most of the research studies are mainly focused upon microbiological and human health care. But in today's era, molecular plant studies are gaining more interest of scientists because these findings are an important and inseparable part of an ecosystem as they are not only food producers but also regulates the balance of gases in atmosphere, and at present plays a significant role in production of transgenics. Plant genetic studies were primarily carried out by conventional breeding. Recent advancement in genetic studies introduced a gene modification technique known as Genetic Engineering which not completely replaces convention breeding technique instead is a better tool with high efficiency. In this article we will discuss about importance of Genetic Engineering, it's comparison with conventional breeding practice as well as its advantages and future aspects.

Key words: Conventional breeding, Genetic engineering and Transgenics.

Introduction:

Conventional breeding was practiced for crop improvement, but the process was time consuming and labour intensive (Christou *et al.*, 2013). Therefore, the recent advancement in recombinant DNA technology and molecular genetics are currently establishing comprehensive changes to the modern society. It still not completely replaces conventional plant breeding though it is a modern tool that helps breeders to fasten their breeding programmes (Kaiser *et al.*, 2020). In this, the dealing with microbes, plants or animal cells to produce desirable products beneficial for the society (Gupta *et al.*, 2016). This area covers an important modern technique i.e., Genetic engineering.

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Genetic Engineering is one that covers advanced technologies manipulating the genome of a host organism to improve and enhance its key values to support sustainable production of food components, energy, bioremediation and even therapeutic derivatives (Wang *et al.*, 2017). Transgenesis is the first artificial genetic modification technique achieved using genetic engineering in which the genes are transferred from one organism to another (Low *et al.*, 2018). It was first introduced by Herbert Boyer and Stanley Cohen in 1973. This is the process to produce transgenic plants whose genomes has been altered by the introduction of a foreign gene or genes from another species (Key *et al.*, 2008). Their genetic material is modified in such a way that does not occur naturally through fertilization or recombination. Examples includes resistance to certain insects, pests' diseases, or severe environmental conditions, or resistance to chemicals (e.g., resistance to an herbicide), or also improving the nutrient profile of the crop (Kumar *et al.*, 2020).

The first transgenic plant was kanamycin-resistant transgenic tobacco line reported in 1983 (Sarkar *et al.*, 2014). Moreover, the major GM crops grown include sugar beet alfalfa, canola, maize, papaya, potato, soybean, squash, cotton and. The farmers recently cultivated approximately 190 million hectares of biotech crops (ISAAA, 2020b). The four primary cultivated crops considered by ISAAA are Maize (~30%), Soybean (~50%), canola (~5%) , cotton (~13%) (ISAAA, 2018, 2020b).

Advantages of genetic engineering over conventional breeding:

1.Genetic engineering have made possible to make more beneficial crop varieties (Muntaha *et al.*, 2016).

2. Unlike selective crop breeding, genetic engineering is more gene-specific and that it introduces specific genes where the end products such as proteins, metabolites or the phenotype are well characterized (Datta, 2013).

3. The process of genetic engineering is much faster than selective breeding raising crops with desired traits such as genetically engineered plants with more desirable traits are drought-resistant plants, disease-resistant crops, plants (e.g., legumes) fortified with more nutrients. Genetic Engineering could increase genetic diversity (Powell, 2012)

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4. In classical breeding the genomes of both the parents are mixed together and gets randomly re-assorted into the genome of the offspring which can result in transmission of undesirable with the desirable genes and therefore leads to linkage drag (Kumar *et al.*, 2020)

5. Moreover, recombinant DNA techniques introduces new traits at one time only excluding extensive crossbreeding as in case of conventional breeding. GM crops benefit the environment by substantially reducing the use of toxic pesticides and herbicides (Brookes and Barfoot, 2016)

Applications of Plant Genetic Engineering:

For sustainability and satisfying the demands of the population effective strategies is required to cope with harsh environmental conditions such as water and nutrient stress, high temperatures that substantially reduce crop yield (Davendra, 2012). In agriculture, the genetic engineering is of great interest that helps in introducing tolerance to environmental stresses in crop cultivars to balance the yield under changing environmental conditions such as herbicide resistance, pest resistance, drought, stress and salinity tolerance (Kumar *et al.*, 2020). GM crop Bt cotton and corn are in which the genes from a bacterium are introduced for resistance against pests which therefore, resulted in decreased use of pesticides (Moellenbeck *et al.*, 2001).

In addition, increased nutritive value of crop has come into light to combat malnutrition in developing countries led to production of several transgenic cultivars with fortified nutritive values such as golden rice with increased beta carotene and enhanced Vitamin A content in it (Key *et al.*, 2008). A high quantity of beta carotene which is believed to protect from night blindness, iron and high-level protein potatoes (Ahmed *et al.*, 2011). Many GM crops include maize with high methionine concentration, canola with high lysine amount and soybean plant with enhanced protein content (Muntaha *et al.*, 2016).

Future Prospects of genetic engineering:

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Genetic engineering has made a tremendous effort since years as many plant species were engineered with improved characteristics (Dalal *et al.,* 2006). With its great success, this technique also faces some of the challenges in assessing gene transfer in transgenics and the major obstacle is gene silencing, which decreases and suppress the expression of gene of interest introduced in the host organism may be due to hypermethylation of incorporated gene (Stam *et al.,* 1997). So, for this reason it is always advised that only a single copy of gene of interest should be introduced inside the genome rather than its multiple copies (Kumar, 2001).

References:

Ahmed, P., Ashraf, M., Younis, M., Hu, X., Kumar, A. and Aisha, N. (2011).Role of transgenic plants in agriculture and biopharming. Biotech. Adv.30 (3): 524-540. Doi: 10.1016/j.biotechadv.2011.09.006.

Brookes, G.; Barfoot, P. GM Crops: Global Socio-Economic and Environmental Impacts 1996–2016; PG Economics Ltd.: Dorchester, UK, 2016

Dalal, M., Dani, R.G. and Kumar, P.A., 2006. Current trends in the genetic engineering of vegetable crops. *Scientia Horticulturae*, *107*(3), pp.215-225.

Datta, A., 2013. Genetic engineering for improving quality and productivity of crops. *Agriculture & Food Security*, *2*(1), pp.1-3.

Deshmukh, R., 2020. Impact of GM Crops on Agriculture Production: A Positive Reflection through Success Stories. *Policy Issues in Genetically Modified Crops: A Global Perspective*, p.161.

Devendra, C., 2012. *Climate change threats and effects: challenges for agriculture and food security*. Kuala Lumpur: Academy of Sciences Malaysia.

Gupta, V., Sengupta, M., Prakash, J., & Tripathy, B. C. (2016). An Introduction to Biotechnology. *Basic and Applied Aspects of Biotechnology*, 1–21. https://doi.org/10.1007/978-981-10-0875-7_1

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multidisciplinary e-Newsletter

ISAAA. (2018). *Global Status of Commercialized Biotech/GM Crops in 2018: Executive Brief*. Ithaca, NY: ISAAA.

ISAAA. (2020b). *ISAAA Brief 55-2019: Executive Summary*. Available Online at: https://www.isaaa.org/resources/publications/briefs/55/executivesummary/default.asp (accessed January 20, 2021).

Kaiser, N., Douches, D., Dhingra, A., Glenn, K.C., Herzig, P.R., Stowe, E.C. and Swarup, S., 2020. The role of conventional plant breeding in ensuring safe levels of naturally occurring toxins in food crops. *Trends in Food Science & Technology*, *100*, pp.51-66.

Kumar, A., Sandhu, N., Venkateshwarlu, C., Priyadarshi, R., Yadav, S., Majumder, R.R. and Singh, V.K., 2020. Development of introgression lines in high yielding, semi-dwarf genetic backgrounds to enable improvement of modern rice varieties for tolerance to multiple abiotic stresses free from undesirable linkage drag. *Scientific reports*, *10*(1), pp.1-13.

Kumar, K., Gambhir, G., Dass, A., Tripathi, A.K., Singh, A., Jha, A.K., Yadava, P., Choudhary, M. and Rakshit, S., 2020. Genetically modified crops: current status and future prospects. *Planta*, *251*(4), pp.1-27.

Low, L.Y., Yang, S.K., Andrew Kok, D.X., Ong-Abdullah, J., Tan, N.P. and Lai, K.S., 2018. Transgenic plants: gene constructs, vector and transformation method. *New visions in plant science. Intech Open, London*, pp.41-61.

Moellenbeck, D.J., Peter, M.L., Bing, J.W., Rouse, J.R., Higgins LS et al. (2001). Insecticidal proteins from Bacillus thuringiensis protect corn from corn rootworms. Nature Biotechnology, 19: 668-672.

Muntaha, S.T., AHMED, A. and AHMED, K., 2016. Applications and Future Prospects of Genetic Engineering: A New Global Perspective. *FUUAST Journal of Biology*, *6*(2), pp.201-209.

Powell, R., 2012. The evolutionary biological implications of human genetic engineering. *Journal of Medicine and Philosophy*, *37*(3), pp.204-225.

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S. Kumar and A. Kumar, "Role of genetic engineering in agriculture," *Plant Archives*, vol. 15, pp. 1–6, 2015.

Sarkar, T., Mandeliya, V., Patel, K. and Patil, A. (2014).Genetic Engineering of Plants through AgrobacteriumMediated Genetic Transformation and its Applications, Mag. Agri. Biol. 13 (5): 148

Wang, X., Chang, S., Lu, J., Fray, R., Grierson, D. and Han, Y., 2017. Plant genetic engineering and genetically modified crop breeding: history and current status. *Frontiers of Agricultural Science and Engineering*, *4*(1), pp.5-27.