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Gene Pollution: The Invisible Genetic Invasion

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Gene pollution refers to the unintended movement of genes flow from one population or variety or species to another through cross pollination and hybridization. With the increasing cultivation of genetically modified crops and the growing use of advanced breeding technologies, the movement of genes beyond their intended boundaries has become an important environmental and agricultural concern. Gene flow may introduce useful traits into related populations, but it can also lead to unintended consequences, including the spread of herbicide or pest resistance, genetic alteration of traditional varieties and potential effects on biodiversity. Therefore, the impact of gene pollution depends on the nature of the transferred gene, the receiving population and the surrounding environment. Understanding gene flow, monitoring its movement and implementing appropriate biosafety and crop management strategies are essential for balancing agricultural innovation with environmental sustainability.

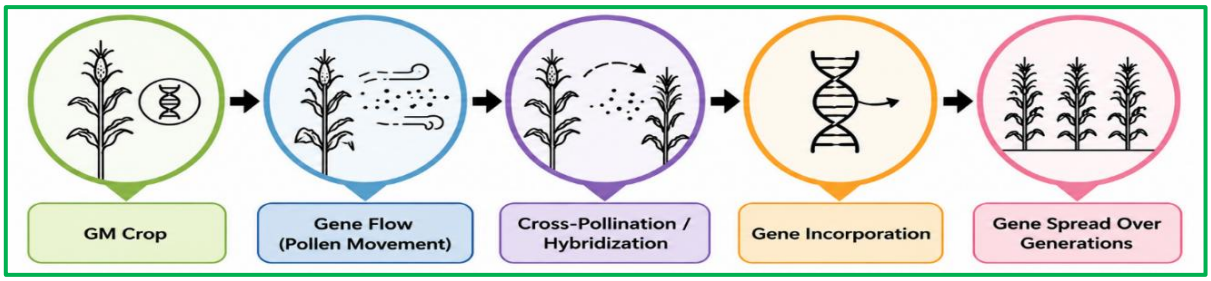
Introduction

Gene pollution refers to the unintended transfer of genetic material from one organism or population to another, which can alter the genetic identity or ecological behavior of the receiving population. The term genetic pollution was popularized by environmentalist Jeremy Rifkin (Sirohi *et al*, 2014). It accounts to the uncontrolled spread of transgenes into the genome of organisms in which such genes are not present in nature (Zaid *et al*, 1999). Transfer of pollen from a genetically modified crop to a wild species or its relatives, the new gene may become incorporated into the wild population by the pollination mechanism later fertilization happen and the new gene gets incorporated into the recipient population and which is passed on to the further succeeding generations. If the transferred gene provides an advantage of resistance to insects, herbicides (Wilson *et al*, 2007), diseases or environmental stress this may pass on to the future generations and it leads to the development of superweeds (plants which develop natural resistance against chemical weed killers). Quist, D. and Chapela, I. (2001) studied on landrace maize grown in Mexico, where introgression from wild relatives is seen as a positive measure to improve cultivated varieties and where introgression occurs as a result of unconscious human actions and the result may be potentially harmful, as might be the case where genetic diversity is lost, making populations more prone to disease or pest attack and the introduction of alien genetic diversity into a host genome is potentially harmful and can be regarded as genetic pollution.

Gene pollution: How does it occur

- Cross pollination: pollen can be carried by wind, insects, birds and other organisms reaches a compatible plant and it fertilizes and this is common in crops like maize, canola, cotton and other cross pollinated species.

- Hybridization: two or more related species or varieties cross, their genetic material may combine to form hybrids. If these hybrids are fertile, the introduced genes can continue to spread in future generations.
- Seed Mixing and accidental spillage: during harvesting, transportation, storage and processing, seeds may accidentally mix. Seeds spilled during transport can germinate outside cultivated fields and establish new populations.
- Movement of plant material: exchange of seeds, cuttings and other plant materials between regions can introduce genes into new environments.
- Gene flow from genetically modified crops: transfer and incorporation of transgenes from genetically modified plants to non-genetic natural population, may produce unexpected genetic combinations which leads to the development of superweeds.



Gene pollution and its impacts in the nature

- Loss of genetic purity: traditional varieties and landraces possess unique genetic characteristics developed over generations. Unwanted gene flow may alter their genetic identity.
- Threat to wild relatives: wild relatives of crops are valuable sources for diverse genes for future breeding, if their genetic composition changes significantly, important genetic diversity may be affected.
- Increased competitiveness: transgene may provide a plant with an advantage under particular environmental conditions, this could increase its competition with native plants (Wilkinson *et al*, 2003).
- Changes in biodiversity: if genetically altered plants become highly competitive, they may influence the abundance and distribution of other species.
- Difficulties in weed management: the movement of herbicide resistance genes may complicate weed control and increase dependence on alternative control measures.

Prevention and its regulation

- Prevent the release of invasive or non-native species into the ecosystem.
- Maintain isolation between genetically modified crops and wilds species.
- Framework of regulatory bodies to asses the harmful effects of GM crops.
- Utilizing the male sterility system to abort the functionality of pollen.
- Establishment of seed bank repositories to reconstruct the native population if genetic pollution occurs.

Conclusion

Gene pollution is an invisible, invasive and irreversible form of genetic change from genetically modified organisms to the native population that can affect the diversity, ecosystem balance and the purity of wild species or landraces. It reminds us that genes do not always remain confined to the organisms or fields in which they were introduced. The movement of genes can sometimes create valuable genetic diversity, while in other situations it may contribute to ecological concerns such as the development of resistant weeds or the alteration of native genetic resources. Gene pollution may be invisible to the eye, but its genetic footprints can extend across generations. Promoting awareness among researchers, farmers and the consumers is equally important to ensure safe use of advanced technologies to the healthier production of nutritionally enriched crops.

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