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RESEARCH ARTICLE

GENETIC POLLUTION AND BIODIVERSITY

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ABSTRACT

Intellectual property rights (IPR) grant inventors monopolies in exchange for their socially valuable innovations, right to privatize plants, animals, and other forms of life. Monopoly control of plants is contributing to the destruction of food security and public interest research, as well as to the loss of biological diversity and ecological health. Genetic pollution indicates to the loss of identity of wild plant species as a result of transfer of genes from crop plants, with engineered fitness genes causing special concern. However, significant reproductive barriers exist between most wild species and crop plants. Gene flow is expected to have its greatest effect on weed species which are closely related to crop plant taxonomically, ecologically and in their reproductive biology. The introduction of genetically engineered (GE) organisms into the complex ecosystems of our environment is a dangerous global experiment with nature and evolution. Genetic pollution is undesirable gene flow into wild populations. The term is usually associated with the gene flow from a genetically engineered (GE) organism (or genetically modified organism - GMO) to a non GE organism. "Genetic pollution" and collateral damage from GE field crops already have begun to wreak environmental havoc. Wind, rain, birds, bees, and insect pollinators have begun carrying genetically-altered pollen into adjoining fields, polluting the DNA of crops of organic and non-GE farmers. Once released, it is virtually impossible to recall genetically engineered organisms back to the laboratory or the field.

INTRODUCTION

The term *genetic pollution* was popularized by environmentalist *Jeremy Rifkin* in his 1998 book *The Biotech Century (Rifkin, Jeremy).* While intentional crossbreeding between two genetically distinct varieties is described as hybridization with the subsequent introgression of genes, Rifkin used genetic pollution to describe the risks that might occur due the unintentional process of genetically modified organisms (GMOs) dispersing their genes into the natural environment by breeding with wild plants or animals(5,8). Genetic pollution accounts to the uncontrolled spread of genetic information (frequently referring to transgenes) into the genomes of organisms in which such genes are not present in nature (Zaid *et.al*., 1999).

Genetically engineered (GE) plants contains genes which have been transferred from unrelated species. These may come from bacteria, viruses, other plants or even animals. If these 'foreign' genes are then transferred into other organisms, this causes genetic contamination or pollution of the natural gene pool (www.greenpeace.org).Unlike other forms of pollution, genetic contamination has the potential to be a problem that multiplies as plants and microorganisms grow and reproduce. Therefore, environmental damage caused by genetically modified organisms (GMOs) cannot be confined to the original habitat in which they are first introduced (www.greenpeace.org). The risk to native biodiversity from gene flow from GE plants is global. For example, in South America, where maize originated, wild varieties of maize will be at risk. In Asia, wild relatives of rice are found close to paddy fields. In North America, wild relatives of squash are common, and in Europe, oilseed rape and sugar beet have wild related plants with which they can cross (*Timmons, A.M. et.al).* If this occurs, not only will the gene pool be irreversibly altered with unknown future consequences, but acquiring the characteristics of the GE plant could turn the wild plants into 'super-weeds' that would be difficult for farmers to eradicate. Tolerance to a chemical weed killer (herbicide tolerance) and insect and disease resistance - the three main types of genetically engineering crops being developed - could all give wild plants an advantage over normal plants and make them more persistent crop. Genetically Modified Organisms may contribute to genetic pollution because artificially created and genetically engineered plants and animals in laboratories, which could never have evolved in nature even with conventional hybridization, can interbreed with naturally evolved wild varieties. Genetically Modified (GM) crops today have become a common source for genetic pollution, not only for wild varieties but also of other domesticated varieties derived from conventional hybridization(www.geenpeace.org*).*

Genetic pollution in plants

- Gene flow occurs from genetically modified plants to sexually compatible non-genetically engineered plants.

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- Gene flow from a GM plant to non-GM plant may occur by wind pollination, or animal pollination.
- Genetic pollution may occur by unknowingly or knowingly providing GM seeds and food as food aid or seed stocks to Third World countries.
- The most well-known example of genetic pollution, often cited by researchers, was the (Quist and Chapela) report of discovery of transgenes from GE maize in landraces of maize in Oaxaca, Mexico. However, this report has since been criticized for insufficient evidence and genetically modified corn did not show up in later studies in the area.
- A clear example of genetic pollution is the genetically modified, herbicide resistant creeping bent grass produced by the Scotts Company. This GM bent grass species was seen, in a 2004 study, to be easily transmitted over long distances by wind pollination to breed with naturally occurring species of bent grass. Give reference

Situations under which genetic contamination arise

Genetic contamination may arise in four situations if

- Wild, related flora growing nearby are pollinated by a GE crop.
- Non-GE or organic crops in neighbouring fields are pollinated by the GE crop.
- A semi-wild, weed or 'feral' population of GE plants develops if the GE crop survives in the agricultural or natural environment.
- Micro-organisms in the soil or the intestines of animals eating the GE crop acquire the foreign genes (www.greenpeace.org).

Biodiversity is traditionally understood to be the basis of food security. The more genetic diversity there is within an agricultural system, the more that system is able to accommodate challenges from pests, disease or climatic conditions.Genetically engineered crops threaten this biodiversity. Once released, new genetically engineered (GE) organisms can interact with other life forms and reproduce, transfer their characteristics and mutate in response to environmental influences. Genetic pollution may be passed on to all future generations of life. One extremely troubling new GE development is the use of crop plants to produce pharmaceuticals and industrial chemicals. These plants could cross-pollinate with related species and contaminate the food supply, and could expose foraging animals, insects and seed-eating birds to a wide range of drugs, vaccines and chemicals. (www.greenpeace.org).

Impact of Genetic Pollution

On Environment

One possible environmental impact of growing GE trees is that they could transfer the introduced genes to their native relatives and other organisms, with unpredictable results. This is possible because GE trees are still closely related to their wild ancestors; they have not undergone thousands of years of domestication. Trees are long-lived perennials that remain in the ground for decades, and that have evolved mechanisms to spread their seeds and pollen over long distances. For example, there is scientific evidence that pine tree pollen can travel a distance of at least 600 km and still germinate. Repeated pollination would increase the odds of the new genes becoming incorporated into natural populations. Environmentalists, politicians, and scientists have long feared that the introduction of genetically modified seeds and plants could cause detrimental effects from "genetic pollution," which occurs when an engineered gene enters another species of crop or wild plant through cross-pollination. This contamination may pose public health threats, create super weeds which could require greater amounts of more toxic pesticides to manage, and threaten extinction for rare plants and their weedy relatives relied upon for crop and plant biodiversity (Bailey, Britt).

On Agriculture

The products of genetic engineering are living organisms that could never have evolved naturally and do not have a natural habitat. (Pollan, Michael).These human-made organisms can reproduce and interbreed with natural organisms, thereby spreading to new environments and future generations in an unpredictable and uncontrollable way. Because we know so little about how these novel organisms will act in the environment, and because these living organisms can multiply and spread, the potentially harmful effects of GE organisms may only be discovered when it is too late. For these reasons, GE organisms (or GMOs - genetically modified organisms) must not be released into the environment. They pose unacceptable risks to ecosystems, and threaten biodiversity, wildlife and sustainable forms of agriculture (www.greenpeace.org).

Causes of Genetic Pollution

- Cross-breeding of GM crops with the wild varieties by cross pollination
- Consumption of GM foods
- Improper disposal of unsuccessful GM crops (*library.thinkquest.org).*

Effects of Genetic Pollution

The transfer of modified genes by wind-blown pollen might wipe out countless species of organisms. For instance, the Bt corn produces wind-borne pollen (able to be spread 1km from farms) that kills the caterpillars of the Monarch butterfly.

1. Gardening job will be tougher as the weeds acquire the modified genes to become super competitive weeds that rampage through the countryside and destroy other life forms in the process.
2. The risk of the evolution of common plant viruses to become more resistant or form new strains will be greatly increased. Microbiologists have come up with an important point that if genetic modification is carried out extensively, new viruses with greater potential to harm mankind may evolve anytime, and the probability of this occurring can be quite high. A research paper commissioned by the British government supports this point. It concludes that crops genetically altered to be resistant to common plant viruses cold risk creating mutant strains that could wipe out the entire forms.
3. The resurgence of the pests from primary pest outbreak to a more destructive secondary outbreak may occur. After a pest has been virtually eliminated by any means, the pest population not only recovers,

but also explodes to higher and more severe levels. This phenomenon is known as resurgence.

4. Abnormalities, mutation, and extinction of species may become widespread and cause a biological havoc that either takes ages to return back to equilibrium or enters a stage of no return. Genes produces proteins in the cells that they are programmed to work in, but when transferred into another system, the proteins may act differently, thus resulting in the outbreak of allergies and the disasters mentioned above.
5. This form of dangerous biotechnology will only benefit largely towards the GM crop farmers in form of monetary gain (Li Benny and Wong Peter).

Genetic risk of Invasive Species

Invasive species hybridize with native species, causing genetic pollution. Plant invasions arising from agricultural, forestry and other activities are becoming of increasing concern worldwide. Such invasions have traditionally been viewed as plants dispersing by seed beyond their intended area of use and becoming weeds. However, in the last decade, genetic invasion by pollen dispersal and hybridization has become of increasing concern (www.rirdc.gov.au). The risk of escape of transgenes from genetically modified organisms has focused public attention on the general issue of hybridization and introgression of genes from planted (exotic species, provenances or selected genotypes) to native gene pools. Indeed, there are already overseas reports of several forest tree species or provenances being under threat of genetic swamping from large, non-native plantings (Potts Brad M et.al). The risks associated with the introduction of non-native species, hybrids and provenances are reviewed. These include direct effects on the gene pool through genetic pollution as well as indirect effects through impacts on other components of biodiversity (Potts Brad M et.al).In many cases the risk of genetic pollution will be small due to strong barriers to hybridization between distantly related species, differences in flowering time or differences in other floral traits. There is no risk of hybridization between species from the different major eucalypt genera/subgenera (e.g. symphyomyrts, monocalypts, eudesmids, bloodwoods and angophora) (www.rirdc.gov.in) .Inter-sectional crosses within *Symphyomyrtus* are unlikely to be successful, or if they are then the hybrids are unlikely to be of sufficient vigour to survive in undisturbed native forests. For example, the probability of successful gene flow between *E. globulus* and the predominantly western distributed mallee groups (*Dumaria* and *Bisectaria*) and potentially the boxes (*Adnataria*) is likely to be low (Mooney H.A. and Cleland E.E.). Even hybrids between relatively closely related species often exhibit reduced vegetative vigour and reduced reproductive output compared to parental types which would limit the possibility of gene flow between planted and native forest gene pools. (www.rirdc.gov.in).

Effect of Genetic Pollution on Biodiversity

Hybridization and Genetics

In agriculture and animal husbandry, green revolution popularized the use of conventional hybridization to increase yield many folds by creating "high-yielding varieties". Often the handful of breeds of plants and animals hybridized originated in developed countries and were further hybridized with local varieties, in the rest of the developing world, to create high yield strains resistant to local climate and diseases. several of the wild and indigenous breeds evolved locally over thousands of years having high resistance to local extremes in climate and immunity to diseases etc. have already become extinct or are in grave danger of becoming so in the near future. Due to complete disuse because of un-profitability and uncontrolled intentional and unintentional cross-pollination and crossbreeding (*genetic pollution*)formerly huge gene pools of various wild and indigenous breeds have collapsed causing widespread genetic erosion and genetic pollution resulting in great loss in genetic diversity and biodiversity as a whole (Sharma, Devinder).

A genetically modified organism (GMO) is an organism whose genetic material has been altered using the genetic engineering techniques generally known as recombinant DNA technology. Genetically Modified (GM) crops today have become a common source for genetic pollution, not only of wild varieties but also of other domesticated varieties derived from relatively natural hybridization (Potts Brad M, et.al, Zaid, A et.al.)(Norman C. Ellstrand, 2004). Genetic erosion coupled with genetic pollution is destroying that needed unique genetic base thereby creating an unforeseen hidden crisis which will result in a severe threat to our food security for the future when diverse genetic material will cease to exist to be able to further improve or hybridize weakening food crops and livestock against more resistant diseases and climatic changes (Sharma, Devinder).

Genetic Pollution and Biotechnology

The newest form of pollution and without doubt the most pernicious and dangerous is genetic pollution, resulting from the widespread dissemination of genes from one organism to another through the uncontrolled use of genetic engineering techniques in combination with natural avenues of gene transfer in the wild.Genes for a variety of unrelated species are engineered into other species with unforeseen results. For example a gene from Brazil nuts, which are frequently allergenic, was inserted into soya beans to make them richer in their distribution of amino acids. However the key protein the gene coded for proved to be the very one causing the allergy. The process was only then terminated. In New Zealand, a nitrogen-fixing bacterium was merged into a saprophytic pine fungus. The engineered variety became pathological and infested the pines, leading to a scare of a fungus epidemic of our productive exotic plantations.

The single most worrying new phenomenon is the development of the so-called *terminator gene* - the death of the immortal germ line. This gene, seen as the elixir of permanent profit by gene tech companies causes all seeds grown after the first generation to become infertile, thus rendering genetically-engineered varieties unable to be grown in perpetuity. In this sense they are no longer living creatures.The invasion of major areas of the planet flooded with such species-unrelated genes could easily lead to dissemination of such a genie out of the bottle of the cultivated species and into wild relatives, where the effects are almost impossible to predict.

With these changes comes the ultimate form of genetic pollution - *genetic cloning* which replaces natural biodiversity and all the almost infinite variation this implies with a mechanical replicon, carrying no new combinations for future disease resistance and completely lacking the variation necessary to sustain a future world whose conditions may be substantially different form our own. Catastrophe could happen because of any natural or astronomical crisis or just the failure of a few germ-plasm banks holding world stocks of the natural varieties or by the contamination of all natural varieties with genes form the engineered ones.

Factors which minimize the risk of genetic pollution

While species choice will be one of the most important factors, there are genetic and silvicultural opportunities that will help minimize the risk of genetic pollution. For example, close spacing in plantations is also known to reduce the abundance of flowers and many of the plantation environments are not conducive to flowering. Flowering on plantation edges may be countered with guard rows of non-hybridizing, inert genotypes. There is considerable genetic variation within the plantation species for reproductive traits and it would be feasible to deploy material secondarily selected for delayed onset or reduced abundance of flowering, or of different flowering time (www.greenpeace.org).

To ensure prevention of genetic pollution there must be

- No commercial releases of GM crops until it is clear they do not cause genetic pollution
- Independent assessment of environmental impact that avoids planting GM crops as far as possible
- Field tests restricted to the assessment of ecological impact on properly contained sites.
- Coexistence rules which aim for no detectable contamination of neighbouring crops and strict liability on biotech companies for any harm arising from the release of their products (including economic harm) (www.Gmfreeze.org).

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