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Enhancing Environmental Conservation through the Implementation of GMOs

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Abstract:

The rapid advancements in genetic engineering have opened new frontiers in agriculture, medicine, and environmental conservation. Among these, the potential of genetically modified organisms (GMOs) in preserving biodiversity and combating environmental challenges has garnered significant attention. This article delves into how GMOs contribute to conservation efforts by bolstering species resilience and curbing biodiversity decline. For instance, the case of ash trees in North America facing the threat of emerald ash borers showcases how genetic modification can aid in rescuing endangered species. The discussion also delves into measures overseeing GMO releases into environments highlighting approaches taken by countries such as the U.S. And China to mitigate risks such as diminished genetic diversity and ecological disturbances. While GMOs offer advantages like lowering greenhouse gas emissions and aiding in toxin breakdown, there are concerns about drawbacks such as displacing species or causing unintended ecological consequences. To address these issues innovative solutions are proposed—like using GMOs that self-terminate after their intended purpose or creating GMOs that establish symbiotic relationships with species.

Keywords: Genetic Modified Organisms, environment, ecosystem, agriculture.

1. Introduction

In recent years, the advancement of genetic engineering has sparked a revolution in various fields, including agriculture, medicine, and environmental conservation. Genetic modification (GM) technologies have opened up unprecedented possibilities for enhancing the resilience of species, improving agricultural productivity, and addressing environmental challenges such as climate change and pollution. As global ecosystems face mounting pressures from invasive species, habitat destruction, and climate change, the need for innovative solutions to preserve biodiversity and maintain ecosystem stability has become increasingly urgent. Among the various applications of genetic engineering, the potential to save endangered species and mitigate biodiversity loss has garnered significant attention. The case of ash trees in North America, which have been severely impacted by the invasive emerald ash borer, exemplifies the critical role that genetic engineering can play in protecting vulnerable species from extinction and safeguarding ecological balance. However, while the promise of genetic engineering is immense, it also raises complex ethical, environmental, and regulatory concerns that must be carefully addressed to ensure its responsible and sustainable use. Globally, the application of genetic engineering in conservation biology is an emerging field, with research efforts focused on developing genetically modified organisms (GMOs) that can withstand environmental stresses, resist pests and diseases, and adapt to changing climates. In the United States, regulatory agencies such as the Food and Drug Administration (FDA), Environmental Protection Agency (EPA), and Department of Agriculture (USDA) have established frameworks to evaluate and monitor the release of GMOs into the environment. These agencies work to prevent potential risks associated with GMOs, such as unintended gene flow, competition with wild populations, and impacts on non-target species. Similarly, international efforts are underway to develop guidelines and protocols for the safe use of GMOs in conservation, with organizations like the International Union for Conservation of Nature (IUCN) and the Convention on Biological Diversity (CBD) playing key roles in shaping global policies. In addition, research institutions and conservation organizations worldwide are exploring the use of gene editing technologies, such as CRISPR-Cas9, to enhance the resilience of endangered species and restore ecological functions in degraded ecosystems[1]. Domestically, in China, genetic engineering research is also gaining momentum, with scientists and policymakers recognizing the potential of

GM technologies to address pressing environmental challenges. The Chinese government has invested heavily in biotechnology research, from 1986-2000, a 2.86 billion RMB (about 400 million USD) budget was funded by the government [2]. Leading to significant advancements in the development of genetically modified crops, such as the Bacillus thuringensis pest-resilient cotton [2]. This innovation alone provided an economic benefit of about $250/ha and a decrease of 70-80% use of insecticides[2]. The Agriculture, Fisheries, and Conservation Department in Hong Kong, for instance, has implemented strict regulations on the release of GMOs into the environment, ensuring that any genetically modified species are carefully assessed and monitored to minimize ecological risks. While the potential benefits of GMOs on the environment are significant, the introduction of genetically modified species into natural ecosystems could also lead to unintended consequences, such as the reduction of genetic diversity, out-competition of native species, and disruption of ecological balance. Therefore, this research seeks to explore the potential of genetic engineering in the environment while critically examining the associated risks and ethical considerations. The goal is to develop a balanced and informed perspective on the use of GMOs in environmental conservation, emphasizing the importance of rigorous regulatory frameworks, ongoing monitoring, and public engagement to ensure that the benefits of genetic engineering are realized without compromising ecological integrity.

2. Genetic modification in ash trees

Ash trees are a significant component of the North American ecosystems, such as hardwood forests and wetlands. Ash trees make up these habitats and are responsible for the shelter and food of native species. Unfortunately, a beetle native to Asia named the emerald ash borer was accidentally introduced to North America in the early 2000s. This invasive species's larva burrows into the tree's bark, preventing efficient water and nutrition transition in the tree, and ultimately kills the tree. The beetles killed hundreds of millions of ash trees, causing irreversible damage to the native ash populations. Conservation organizations are striving their best to protect the ash populations through the use of insecticides. While insecticides might be effective, it is not a long-term solution as it requires regular maintenance by humans. Dr. Laura J. Kelly, an academic visitor at Queen Mary, Research Leader in Plant Health at the Royal Botanic Gardens states, "Our findings suggest that it may be possible to increase resistance in susceptible species of ash via hybrid breeding with their resistant relatives or through gene editing" [3]. Fortunately, through gene engineering, ash trees in North America would be able to produce chemicals that are harmful or repel insects, which means they will be resistant to emerald ash borers, thanks to genetic engineering. Genetic engineering would be greatly beneficial for endangered species that are facing climate change, invasive species, or other threats. Similar to the ash trees, it is necessary that other endangered species are supported by genetic engineering technologies to prevent extinction, and hence protect biodiversity. Biodiversity is crucial for the ecosystem; every organism supports each other to form a healthy ecosystem. Losing any species would have impacts on the whole ecosystem; therefore, maintaining biodiversity is crucial for the environment.

2.1 GMO Regulations

It is necessary to save endangered species with genetic engineering technologies and prevent biodiversity loss, but at the same time, there is a risk of losing biodiversity when introducing GM species to the wild. Conflicting situations like this make the topic of GMOs extremely controversial, but there are ways to make GMOs better by preventing risks. There are regulation departments that help to prevent hazards from GMOs. For example, the U.S. Food and Drug Administration (FDA), U.S. Environmental Protection Agency (EPA), and U.S. Department of Agriculture (USDA) are some departments in the United States of America that regulate GMOs and watch over the modified species in the environment [4]. With the help of these agencies, unwanted genes would be unlikely to enter the native populations, thus preventing risks like GM plants from competing with others. Furthermore, according to the Agriculture, Fisheries, and Conservation Department in Hong Kong, "no one is allowed to release a GMO into the environment unless the GMO has been exempted by the Secretary for the Environment and Ecology" [5]. This legislation prohibited people from jeopardizing the environment and at the same time allowed scientists to save endangered species using genetic engineering after it is exempted. Government intervention as such would enhance the use of GMOs.

2.2 Potential risks

Genetically modified plants are designed to be more competitive, so when GM (genetically modified) species are introduced to the wild, there is a likelihood that the non-GM variants might be out-competed. This leads to a situation where the population of a certain species becomes more genetically similar to the GM variants, in other words, decreasing in genetic diversity. A low genetic diversity in a species results in vulnerability to changes [6]. Due to the high similarity of genes, how individuals act under harsh conditions would also be similar [6]. Therefore, if an individual cannot withstand a disease, then it is likely that the majority or even the whole population will be wiped out in a short time. This decreased genetic diversity leads to populations of plants having a lower tolerance to changes, and there is an increased risk for species to go extinct. On the other hand, having a diverse gene pool means that there are traits in different individuals that could withstand different harsh conditions. Gene diversity could prevent the population from being critically damaged by a few harsh conditions, which gives time for recovery. That being so, GM species lead to a loss of genetic diversity and, hence, loss of biodiversity. In addition, GM plants could also out-compete other species by their fast growth rate, taking over space and nutrition. This can also lead to a loss of biodiversity as GM individuals are taking over an ecosystem.

2.3 Reduced carbon emissions

While the use of GMOs benefits the ecosystem, it also helps improve the environment worldwide. The use of GM crops in agriculture is reducing GHG (greenhouse gas) emissions, efficiently mitigating climate change. GM crops are tolerant to pests and herbicides, therefore improving the farmers' control over weeds, which lowers the need for soil preparation [7]. Soil preparation includes plowing, leveling, and maneuvering, which all require diesel/fuel. By reducing the reliance on soil preparation, GM crops help reduce fuel use, hence carbon emissions. In 2020, approximately 23,631 million kg of carbon dioxide was reduced by the use of GM crops [7]. In addition, due to the trait that GM crops are resistant to pests, the use of insecticides has greatly reduced. From 1996-2020, the dosage of pesticides had decreased by 748 million kg [8]. Because of the decreased usage of pesticides, soil is slowly recovering from erosion; this is shown by soil carbon sequestration. From 1994-2020, soil sequestered 93,745 million kg of carbon, equivalent to 344,044 million kg of unreleased carbon dioxide, or the sum of carbon emissions of 228 million cars for 24 years [7]. As a result of decreased carbon emissions and lowered carbon levels in the atmosphere, the greenhouse effect would also be reduced. Consequently, less excess heat is trapped within the atmosphere, which mitigates global warming and ultimately climate change. By reducing climate change, the global environment would be improved.

2.4 Economic benefits

Not to mention, GM crops benefit the world economy by both reducing costs and increasing yields. GM herbicide-tolerant crops reduced the expenses on weed control; this includes fuel, equipment repair, and machinery for soil preparation and mechanical weed removal. Due to the utilization of the non-tillage method or no soil preparation, the production cycle of crops is reduced. This allowed farmers to plant two crops in the same growing season; this made a huge difference in yields, with an additional 122 million tonnes from 1994-2012 [9]. From 1994-2012, there was an increase of 37 billion dollars in farm income brought by GM soybeans worldwide, about 23 billion of which was due to cost savings, and the other 14 billion brought by increased yields [9]. Similarly, other GM crops such as maize, cotton, and canola have seen a significant increase in income [9]. On top of that, the increased yields result in greater food availability. With the increased availability, areas where there are limited food and hunger issues would decline. In areas where food is not a problem, food prices would drop as the supply increases. The help of GM crops gave rise economically in the agriculture industry and increased the quality of life for individuals.

2.5 GMOs decomposition of toxins

GMOs could even help decompose chemical compounds that are released into nature due to human activities. Biodegradation of oil spills, halo benzoates, naphthalenes, toluene, trichloroethylene, octanes, xylenes, etc. is possible [10]. By bioengineering bacteria, fungi, and algae, they can degrade these contaminants more efficiently compared to natural individuals [10]. This is an alternative option to clean up contaminated habitats as it is more cost-effective and safe [10]. These chemicals are all very hard or take very long to decompose naturally, plastics have similar properties and are a major source of pollution in nature. There might be ways that organisms could be genetically engineered to be able to effectively decompose plastic. If this is an achievable invention, governments should have strong support for scientists and encourage such innovations to happen. There would be countless benefits with efficient plastic decomposition possible, just to name a few: preventing biodiversity loss, habitat recovery, reducing costs in clean-up programs, etc. [10].

2.6 Possible innovations for improvement

While having numerous advantages, we cannot ignore the potential risk GMOs bring, there are some ways that scientists could lower these risks through further development in the area. One possibility is using modified organisms that naturally fade away once they have completed their assigned tasks. These organisms will be created with self-destruction mechanisms ensuring that once they have achieved their goals – like eradicating species, detoxifying areas, or controlling disease carriers – they gradually disappear from the environment. This gradual disappearing act helps reduce the risk of GMOs becoming invasive or disrupting ecosystems in the run. For instance, specific gene modifications could be set to deactivate after a certain number of generations or GMOs could be designed with triggers that activate self-destruction limiting their spread beyond areas. By phasing out these GMOs scientists can tackle issues without changing ecosystems or diminishing genetic diversity. Furthermore, modified organisms could be engineered to establish symbiotic relationships with native species. Rather than competing with organisms or overpowering them, these GMOs enhance ecosystem functions by promoting beneficial interactions. For instance, a modified plant might be engineered to boost the well-being of pollinators or improve nitrogen fixation through symbiosis, with microbial species. This not only supports ecosystem health but might also benefit endangered species. This strategy has the potential to transform conservation efforts by enabling GMOs to become part of ecosystems in a manner that benefits and strengthens processes sidestepping the disturbances typically associated with conventional GMO use. By implementing innovative strategies, GMOs can be used to improve the ecosystems while not posing a threat.

3. Conclusion

The use of engineering, in conservation presents exciting opportunities as well as daunting challenges. This essay has delved into the benefits of modified organisms (GMOs) in safeguarding endangered species combating biodiversity decline and tackling environmental issues like climate change and pollution. This paper shows how GMOs can boost the resilience of species such as ash trees in North America cut down on greenhouse gas emissions through GM crops and clean up environments. The essay also highlights the dangers linked to releasing GM species into habitats, including risks like reduced diversity, displacement of native species and unintended ecological impacts. Regulatory frameworks set up by organizations like the FDA, EPA and USDA—and international guidelines—play a role in managing these risks to ensure that genetic engineering benefits are realized without harming ecosystems. The importance of this study lies in its assessment of engineering's dual role in conservation—as a valuable tool for preserving biodiversity and a potential threat to ecological balance. By analyzing how effective GMOs are for conservation efforts while acknowledging associated risks this research adds insights to the ongoing discussion about responsibly using genetic technologies, for environmental protection. However, there are some limitations, to the research. The long-term effects of GMOs on ecosystems are still not complete. Thorough field studies and monitoring are needed to evaluate their impacts over time. Furthermore exploring the aspects of using engineering in conservation, especially in terms of public perception and acceptance is crucial. Moving forward future research should concentrate on enhancing the precision and safety of genetic engineering technologies establishing frameworks and promoting global cooperation to tackle the challenges of biodiversity loss and environmental degradation. By weighing the risks and benefits genetic engineering could become a tool, for protecting the biodiversity of our planet and ensuring a sustainable future.

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