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# Fight Global Warming with Genetically Altered Trees

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## ABSTRACT
Genetically modified plants are simply plants, whose genetic material has been modified. Forests of genetically altered trees and other plants could sequester several billion tons of carbon dioxide from the atmosphere and convert it into long-lived forms of carbon, first in vegetation and ultimately in soil and so help ameliorate global warming. Besides increasing the efficiency of plant's absorption of light, researchers might be able to genetically alter plants so they send more carbon into their roots--where some may be converted into soil carbon and remain out of circulation for centuries. Other possibilities include altering plants so that they can better withstand the stresses of growing on marginal land and so that they yield improved bioenergy and food crops. Drought resistant plants can be produced by the use of genetic engineering, so that they can withstand in the stressed environment. The genetically altering plants, thereby increasing the efficiency of plant's absorption of director scattered sunlight; making them send more carbon into their roots where some may be converted into soil carbon and remain out of circulation for centuries; making them better able to withstand the stresses of growing on marginal land, improving their yield, in terms of bioenergy and food crops. A combination of such genomic improvement might enormously increase the amount of carbon that vegetation naturally extracts from air. Such innovations might, in combination, boost substantially the amount of carbon that vegetation naturally extracts from air.

**Key words:** Global warming, GM plants, transgenic, carbon dioxide, green house gases

## INTRODUCTION
Global warming is defined as the increase in the average measured temperature of the Earth's near-surface air and oceans and its projected continuation. The rising of Earth's temperature is govern by exotic components like water vapor, carbon dioxide ($CO_2$), ozone, methane ($CH_4$), nitrous oxide ($N_2O$) and Chlorofluorocarbons (CFCs) that absorb heat and thus increase atmospheric temperatures and results in disasters like hurricanes, droughts and floods which are becoming more frequent. The unexpected temperature rising is mainly because of the increase in atmospheric green-house gases due to anthropogenic activities: man cuts down the forest for timber or clear land for agricultural farming, industries or increasing human habitations. This extensive deforestation reduces the number of trees available to absorb carbon dioxide (Hsu *et al*., 2009). Thus the production and mass cultivation of genetically altered trees can absorb more amount of carbon dioxide from the atmosphere and convert it into long-lived forms of carbon, first in vegetation and ultimately in soil and so help ameliorate global warming.

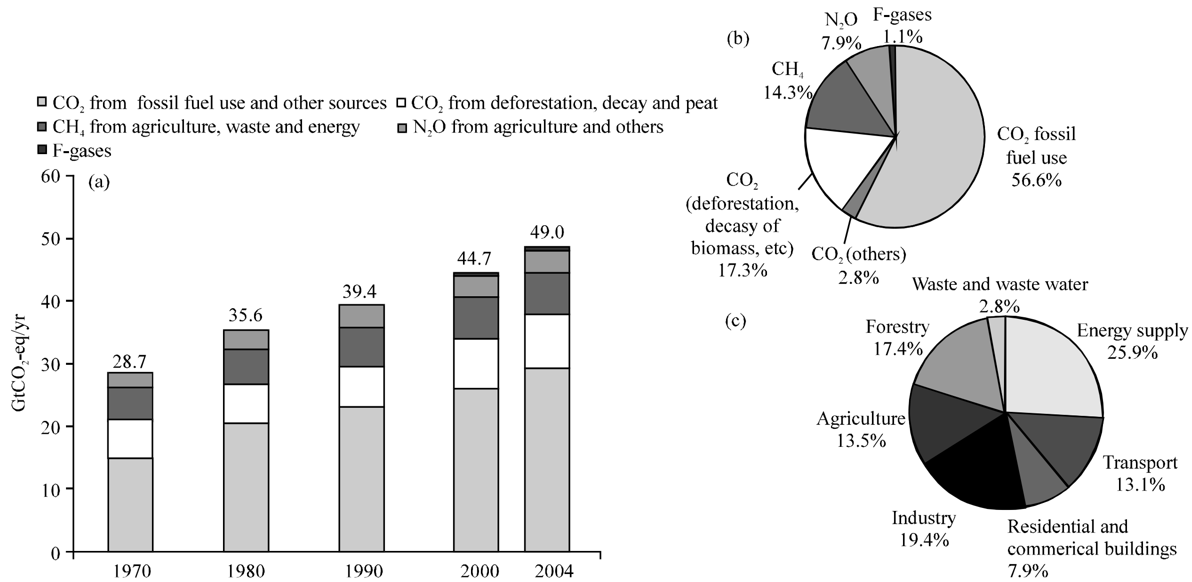


Fig. 1: Global anthropogenic greenhouse gases emissions (a) Global annual emissions of anthropogenic greenhouse gases from 1970 to 2004 (b) Share of different anthropogenic greenhouse gases in total emissions in 2004 in terms of $CO_2$ (c) Share of different sectors in total anthropogenic greenhouse gases emissions in 2004 in terms of $CO_2$ (IPCC, 2007)

## GREENHOUSE GASES

Over the past few decades, global warming due to elevated $CO_2$ and other greenhouse gases has remained an issue of concern for researchers, environmentalists and policy makers (Azam and Farooq, 2005a). Carbon dioxide, methane, nitrous oxide, chloro-fluorocarbons comprise the major greenhouse gases (Fig. 1). Among these greenhouse gases, both carbon dioxide and methane play major roles in greenhouse effect. These gases in combination with water vapour make a blanket like layer around the earth and prevent heat from escaping to keep the global average temperature within biologically active range. This effect is called greenhouse effect and the gases which can absorb the heat radiation from the earth are therefore called greenhouse gases. Greenhouse gases are increasing rapidly as a result of anthropogenic activities, particularly continued deforestation and the burning of fossil fuels to provide living space and energy for an expanding population (Hsu *et al.*, 2009).

## CARBON DIOXIDE

Carbon dioxide is the most important anthropogenic greenhouse gas which leads to an increase in atmospheric temperature and continues to heat for decades to centuries. It represents 77% of total anthropogenic greenhouse gas emissions in 2004 (Fig. 2). Although carbon dioxide is not a powerful greenhouse gas but it plays major role in greenhouse effect. In <50 years, $CO_2$ concentration has increased from 316 to 370 ppm with a current increase of about 1.8 ppm per annum (Kimball *et al.*, 1997). The concentration of $CO_2$ is likely to double in the present century (King *et al.*, 1992), especially if the pace of development continues; finding alternative ways of fuel/energy notwithstanding. This increase will enhance the global greenhouse effect and in changed distribution of rainfall and other weather components. These changes will have a significant bearing on terrestrial plants at both individual and ecosystem levels (Azam and

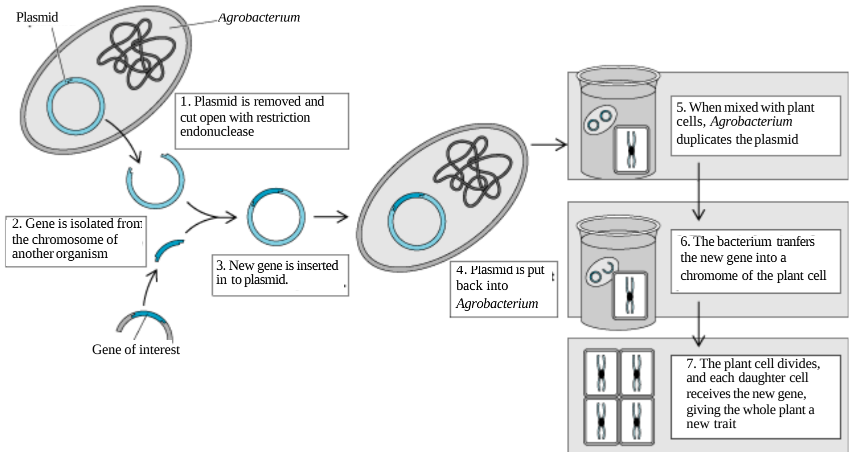


Fig. 2: *Agrobacterium* vector method. The Ti plasmid of the plant bacterium *Agrobacterium tumefaciens* is used in plant genetic engineering (Raven and Johnson, 2002)

Farooq, 2005b). Carbon dioxide is the sole source of carbon used by all plants during photosynthesis. Photosynthesis is a process by which plants use sunlight, water and carbon dioxide to produce carbohydrates and other biological compounds which reduces the amount of carbon dioxide in the air. This, in turn, helps reduce global warming. Thus plants behave as the lungs of the Earth.

**Fight global warming with genetically altered trees:** Forests of genetically altered trees and other plants could sequester several billion tons of carbon from the atmosphere each year and so help ameliorate global warming, according to estimates published in the October issue of Jansson *et al.* (2010). The study, by researchers at Lawrence Berkeley National Laboratory and Oak Ridge National Laboratory, outlines a variety of strategies for augmenting the processes that plants use to sequester carbon dioxide from the air and convert it into long-lived forms of carbon, first in vegetation and ultimately in soil. Their quantitative analysis indicated that forests of genetically altered trees and other plants could sequester several billion tons of carbon from the atmosphere each year. That would help to ameliorate global warming, whatever one's ideology on genetic engineering and one's ideology on climate change. The researchers stress that the use of genetically engineered plants for carbon sequestration is only one of many policy initiatives and technical tools that might boost the carbon sequestration already occurring in natural vegetation and crops.

**Genetically modified crops:** Genetic modification is the newest scientific tool for developing improved crop varieties. Such crops can help to enhance agricultural productivity, boost food production, reduce the use of farm chemicals and make our environment healthier. Genetic engineering involves the manipulation of genes within a species and may also involve the transfer of genes-and thus the characteristics governed by those genes-from one species to another.

**Traditional plant breeding:** Humans have been modifying crop plants ever since farming began 10,000 years ago, when wild plants were first domesticated to provide food, feed and fiber.

Traditionally, this modification was accomplished primarily through selection of desirable plant types but more recently by plant breeding which involves the crossing of plants with desirable traits, followed by many generations of selection to eliminate undesirable traits acquired from wild plants. Thus, every crop is a product of repeated genetic adjustment by humans over the past few millennia. While this process has provided the current crop varieties, it is slow and arduous. In addition, the traits for which plants can be bred are limited to those that occur in the wild in closely related crop species; it has not been possible to incorporate characteristics that occur only in non-related species.

**Genetic modification technology:** Recombinant deoxyribonucleic acid (DNA) technology is the most recent tool employed by crop breeders to improve traditional methods of incorporating desirable traits and to eliminate undesirable characters. Genetic modification technology while providing greater precision in modifying crop plants, enables scientists to use helpful traits from a wider pool of species to develop new crop varieties quickly. Genetic modification involves a clear-cut transfer of one or two known genes into the plant genome-a surgical alteration of a tiny part of the crop's genome compared with the sledgehammer approaches of traditional techniques, such as wide-cross hybridization or mutation breeding which bring about gross genetic changes, many of which are unknown and unpredictable. Further-more, unlike traditional varieties, modern GM crops are rigorously tested and subjected to intense regulatory scrutiny for safety prior to commercialization.

**Gene transfer:** The direct transfer of genes into plants is achieved through a variety of means but the *Agrobacterium* vector and the gene gun methods are the most common.

**Agrobacterium vector:** *Agrobacterium tumefaciens* is a soil-borne natural pathogen that causes tumors in plants by transferring a piece of its DNA to plant cells. The bacterial cells harbor a large plasmid, called Ti (tumor-inducing) plasmid which carries the tumor-causing genes in a region of the plasmid called T-DNA. Scientists have modified this bacterium to eliminate disease-causing genes from the T-DNA region, enabling the disarmed bacterium to deliver desirable bacterial genes, such as those for insect resistance, to the plant cells. The resulting plants grown from such cells are healthy but contain the newly introduced gene in every cell expressing the desired trait (Fig. 2). Research on *Agrobacterium tumefaciens* mediated genetic transformation has been successful and considerable progress has been made in making different rice genotypes amenable for regeneration and transformation (Azhakanandam *et al*., 2000; Rachmawati *et al*., 2004; Rajesh *et al*., 2008).

The *Agrobacterium* approach is the most popular method used to deliver genes to plant cells because of the clean insertion and low-copy number of the inserted genes. However, this bacterium does not readily infect monocotyledonous crops, such as wheat, rice and corn. Scientists have genetically engineered new plasmids to help overcome this problem and the *Agrobacterium* method is now being employed to transfer genes into cereal crops such as rice.

**Gene gun:** In the gene gun technique (also called particle bombardment or the Biolistic® approach), microscopic particles coated with the DNA fragment representing the desired gene are shot into the plant cells using a special device. A small proportion of the DNA which enters the cells becomes incorporated into the chromosomes of the plant cell. The gene gun technique helps overcome some of the deficiencies of the *Agrobacterium* method (such as bacterial contamination, low-efficiency transfer to cereal crops and inconsistency of results).

**GM plant development:** With any method of gene transfer, the plant cells containing the introduced gene are allowed to develop into full plants under tissue-culture conditions. To ensure that only the modified cells are grown into full plants, scientists include an antibiotic-resistant marker gene along with the desired gene to be introduced into plant cells. When plant tissues are cultured in a medium containing phytotoxic antibiotics, such as kanamycin, only those genetically modified cells containing the marker gene are able to survive and proliferate. This helps scientists to selectively allow a few genetically transformed plant cells (among a mass of millions of untransformed cells) to develop into full plants.

**Drought and salt resistant plants:** Drought due to global warming limits the agricultural production by preventing the crop plants from expressing their full genetic potential (Mitra, 2001). Drought is a recurring extreme climate event over land characterized by below-normal precipitation over a period of months to years. Drought is a temporary dry period, in contrast to the permanent aridity in arid areas. Drought occurs over most parts of the world, even in wet and humid regions. This is because drought is defined as a dry spell relative to its local normal condition. On the other hand, arid areas are prone to drought because their rainfall amount critically depends on a few rainfall events (Sun *et al*., 2006).

Yeo *et al.* (2000) developed genetically engineered potato plants by introduction of the Trehalose-6-Phosphate Synthase (TPS1) gene from *Saccharomyces cerevisiae*. The overall aim of genetically improving crops for drought resistance is to develop plants able to obtain water and use it to produce sufficient yields for human needs under drought conditions (Fig. 3). While advances have been made in developing crops that are genetically improved with traits such as herbicide and pesticide resistance, attempts to improve plant drought resistance have been hindered by the complexity of plant drought resistance mechanisms at the whole plant, cellular, metabolic and

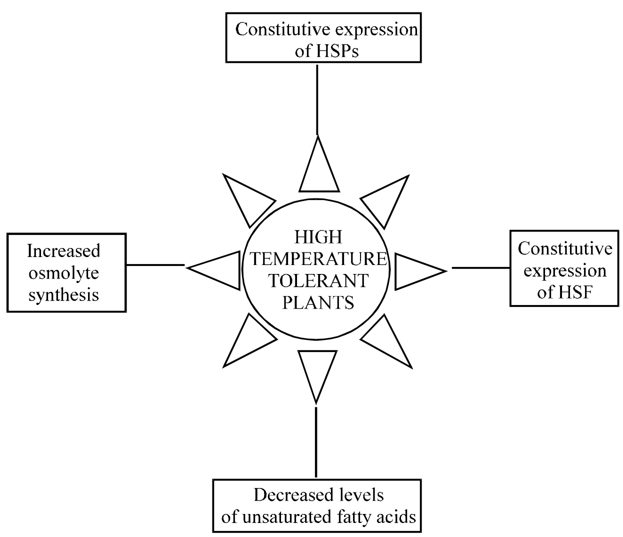


Fig. 3: Strategies employed for producing high temperature-tolerant transgenic plants. Strategies 1 and 3 operate via increased synthesis of heat shock proteins. Strategy 2 leads to better water relations of the cell. Strategy 4 pertains to improved photosynthesis under stress conditions through requisite change in lipid biochemistry of the membranes (Grover *et al*., 2000)

genetic levels. Interactions between these mechanisms and the complex nature of drought itself, adds another layer of intricacy to this problem.

Due to the global warming, salt stress is one of the major stresses faced by plants which adversely affect their productivity, affects large terrestrial areas of the world; the need to produce salt-tolerant crops is evident (Joseph and Jini, 2010). The introduction of the transcription factor YAP1 gene, originally from yeast (*Saccharomyces cerevisiae*), into *Arabidopsis thaliana* plant showed tolerance to various NaCl concentrations (Joseph and Jini, 2011).

**Strategies to lower greenhouse gas level by rice agriculture:** Agriculture practices such as rice based cropping system is considered as the major greenhouse gas emitter (Banker *et al.*, 1995; Wassmann and Aulakh, 2000) which contributes a major portion of all global emissions. Rice plant absorbs carbon from the atmosphere but if the plant cannot utilize it efficiently, the carbon is dispersed into the soil where it converts to methane. Under these situations, global warming now-a-days has become an important issue.

Rice (*Oryza sativa* L.) is one of the most important stable food crops in the world (Joseph *et al.*, 2010). It serves as a main food source for more than 3 billion people around the world in 2004, especially in Asia. More than 90% of the world's harvested rice area is in Asia. According to the estimates from the latest Food and Agriculture Organization (FAO) of the United Nations, paddy production increased by 1.4% in 2007 to 650 million tones. The expansion of production would be on account of a 1.0% increase in the area harvested to 157.5 million hectares and of a modest gain in average yields from 4.12 to 4.14 tones per hectare (Fig. 4).

With rapid population growth, most Asian countries encounter domestic supply constraints. They have to import rice even to supplement their own rice production. The problems rose from the need of rice production have become an internationally hot issue. Uncertainties become even greater as rice cultivation itself has a significant effect on global warming through the emission of greenhouse gases, carbon dioxide and methane.

In response to the threat of global warming a variety of policy measures have been proposed to reduce the emissions of carbon dioxide ($CO_2$), the most important greenhouse gas under the control of human activity. Carbon dioxide which has been estimated to have contributed 50-60% of the warming in the last century, is released during fossil fuel combustion and deforestation. Proposed national policies and global agreements have focused on reducing carbon emissions from these sources.

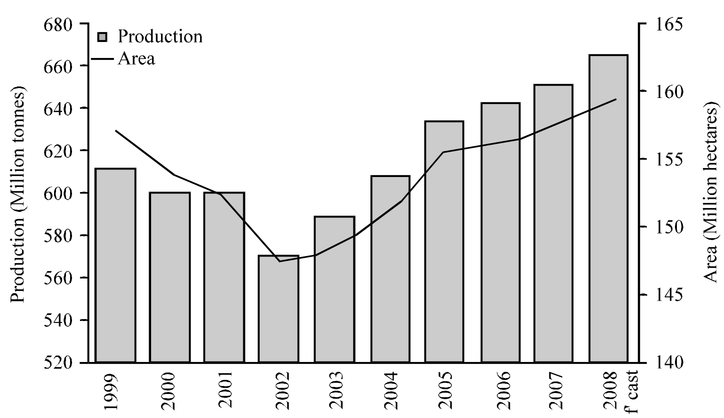


Fig. 4: Global rice paddy production and area (FAO 2008)

## CONCLUSION

United Nations and other sources indicate that world population could grow upto about 8.5 billion by 2025 (Keyfitz, 1989) and to 11 billion by the end of the coming century. Global agricultural production of rice will need to increase several times from present levels to meet the needs of food. However, agriculture accounts for 14 and 52% of global anthropogenic carbon dioxide and methane emissions, respectively. The emission of greenhouse gases in rice paddy could be mitigated accompanied with increased irrigation, fertilizer use and developing new high-yield rice varieties. However, the cost is too high to farmers and they are reluctant to drain the field or apply measure by employing more labors. For this reason, it is urgent that we develop other strategies to lower global warming, by biotechnology to manipulate genes or by integrated management system. Genetic engineering is an effective strategy to control greenhouse gases from rice but it needs long term field test and may have a potential side effect on human safety and our environment. Integrated management system is also an effective and even better strategy. The integrated management system can be applied to plant production immediately to relieve the global warming right away. In this case, integrated management system seems a more powerful way to reduce greenhouse gases in short-term. There will be a great potential to stabilize or even reduce greenhouse gases from the atmosphere while increasing plant production without dramatically changing cultural practices if we can combine both technologies in the future.

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