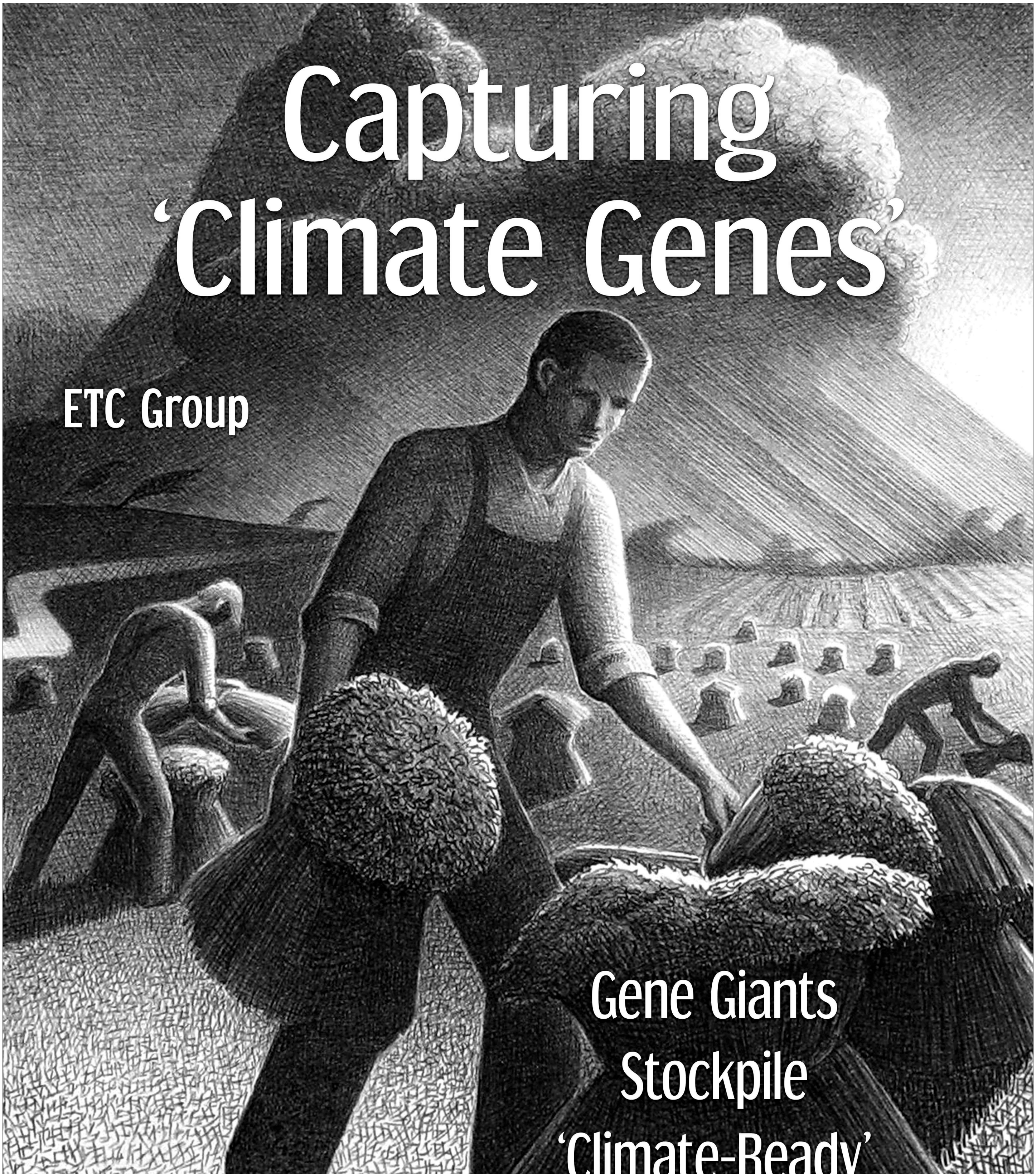
# Capturing 'Climate Genes'

ETC Group



## Gene Giants Stockpile 'Climate-Ready' Patents

# Overview

## Issue:

The world's six largest agrochemical and seed corporations are filing sweeping, multi-genome patents in pursuit of exclusive monopoly over plant gene sequences. Marketed as crops genetically-engineered to withstand environmental stresses such as drought, heat, cold, floods, saline soils, and more, this development could lead to control of most of the world's plant biomass – whether it is used for food, feed, fibre, fuel or plastics. Under the guise of developing "climate-ready" crops as a silver bullet solution to climate change, these companies are pressuring governments to allow the broadest and potentially most dangerous patent claims in intellectual property history. But can patented techno-fix seeds provide the adaptation strategies that small farmers need to cope with climate change? On the contrary, these proprietary technologies are poised to concentrate corporate power, drive up costs, inhibit independent research, and further undermine the rights of farmers to save and exchange seeds. For the "Gene Giants," the goal is "biomasstery" – to profit from the world's biomass.

## Actors:

At least 261 patent families (subsuming more than 1663 patent documents) published between June 2008-June 2010 make specific claims to confer "abiotic stress tolerance" (from drought, heat, flood, cold, salt) in plants. The claims extend beyond a single engineered plant species to substantially similar genetic sequences in virtually *all* engineered food crops, extending, in many cases, even to the harvested food and feed products. Just six Gene Giants (DuPont, BASF, Monsanto, Syngenta, Bayer and Dow) and their biotech partners (Mendel Biotechnology and Evogene) control 201, or 77%, of the 261 patent families (both issued patents and applications). Three companies (DuPont, BASF, Monsanto) account for 173 or 66%.

## Impact:

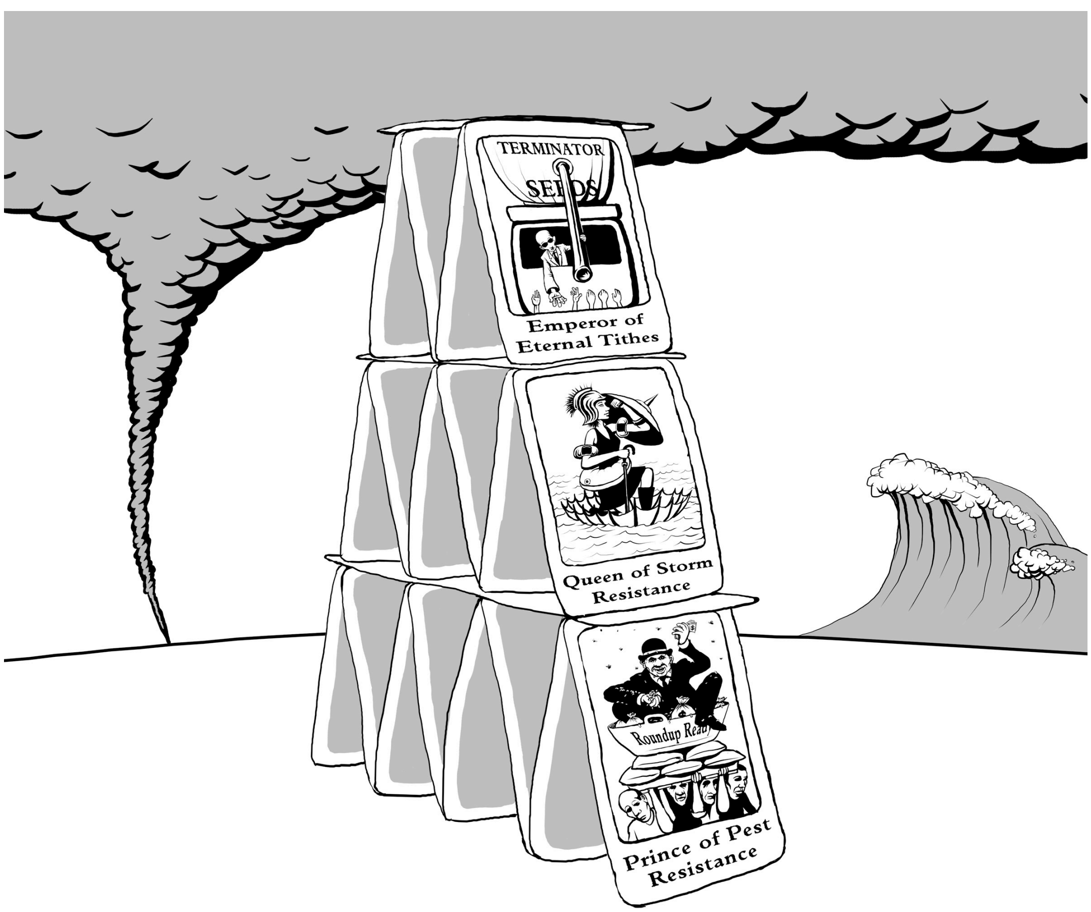
Farming communities in the global South – in other words, those who have contributed least to global greenhouse emissions – are among the most threatened by climate chaos. The patent grab on so-called climate-ready traits is sucking up money and resources that could be spent on affordable, farmer-based strategies for climate change survival and adaptation. The patent grab on "climate ready" crops is a bid to control not only the world's food security but also the world's yet-to-be commodified biomass. In the fog of climate chaos, the Gene Giants hope to ease public acceptance of genetically engineered crops and make the patent grab more palatable. It's a fresh twist on a stale theme: Crops engineered with "climate-ready" genes will increase production and feed the world. Plants that are engineered to grow on poor soils, with less rain and less fertilizer will mean the difference between starvation and survival for the poorest farmers. To gain moral legitimacy, the Gene Giants are teaming up with high-profile philanthropists (Gates, Buffett), big governments like the USA and UK, and big-box breeders (Consultative Group on International Agricultural Research) to donate royalty-free genes and technologies to resource-poor farmers, especially in sub-Saharan Africa. The *quid pro quo*, of course, is that Southern governments are obliged to "ease the regulatory burden" that could hinder the commercial release of transgenic crops and embrace biotech-friendly intellectual property laws.

## Stakes:

The global market for maize marketed as drought-tolerant is an estimated $2.7 billion,[1] but the US Department of Agriculture predicts that the global bio-based market for chemicals and plastics, alone, will top $500 billion per year by 2025.[2]

## Policy:

**There is no societal benefit when governments allow six corporations to monopolize food.** The pretext of indispensible so-called climate-ready genes will increase farmer dependence on GM crops, jeopardize biodiversity, and threaten global food sovereignty. Governments must suspend the granting of all patents on climate change-related genes and traits. There must be a full investigation, including of the social and environmental impacts of these new, un-tested varieties. Given the global state of emergency, ETC Group urges inter-governmental bodies to identify and eliminate policies such as restrictive seed laws, intellectual property regimes, contracts and trade agreements that act as barriers to traditional plant breeding, seed-saving and exchange. Restricted access to germplasm is the last thing farmers need in their struggle to adapt to rapidly changing climatic conditions. Farmer-led strategies for climate change survival and adaptation must be recognized, strengthened and protected.



## Overview: The Potential Impact of Climate Change on Agriculture and Food Systems in the South

Scientists predict that many of the poorest people in the global South will suffer the most damaging impacts of climate change. The United Nations 2007/2008 *Human Development Report* warned that the consequences of climate change could be "apocalyptic" for some of the world's poorest.[3]

Human-induced climate change is triggering shocks in all ecosystems. Profoundly affected will be crops, livestock, fisheries and forests and the billions of people whose livelihoods depend on them. First and most negatively affected will be agriculture and food systems in South Asia and Southern Africa. Extreme climate events (especially hotter, drier conditions in semi-arid regions) are likely to slash yields for maize, wheat, rice and other primary food crops. Recent studies on the potential impacts of climate change on agriculture in the developing world offer a uniformly grim prognosis. Consider the following examples:

- A temperature increase of 3–4 degrees Celsius could cause crop yields to fall by 15–35 percent in Africa and west Asia, and by 25–35 percent in the Middle East, according to an FAO report released in March 2008.[4]

- 65 countries in the South, most in Africa, risk losing 280 million tonnes of potential cereal production, valued at $56 billion, as a direct result of climate change.[5]

- Projected increases in temperature and changes in rainfall patterns will decrease growing periods by more than 20 percent in many parts of sub-Saharan Africa. The most vulnerable communities across Africa are farming families in East and Central Africa, including Rwanda, Burundi, Eritrea, and Ethiopia as well as Chad and Niger.[6]

- Farmers in dryland areas of sub-Saharan Africa will experience revenue losses of 25% per acre by 2060. The overall revenue losses of $26 billion per annum would exceed current levels of bilateral aid to the region.[7]

- Asian rice yields will decrease dramatically due to higher night-time temperatures. With warmer conditions, photosynthesis slows or ceases, pollination is prevented, and dehydration sets in. A study by the International Rice Research Institute reports that rice yields are declining by 10% for every degree Celsius increase in night-time temperatures.[8]

- South Asia's prime wheat-growing land – the vast Indo-Gangetic plain that produces about 15% of the world's wheat crop – will shrink 51% by 2050 due to hotter, drier weather and diminished yields, a loss that will place at least 200 million people at greater risk of hunger.[9]

- Latin America and Africa and will see a 10% decline in maize productivity by 2055 – equivalent to crop losses worth $2 billion per year.[10]

- In Latin America, losses for rain-fed maize production will be far higher than for irrigated production; some models predict losses of up to 60% for Mexico, where around 2 million smallholder farmers depend on rain-fed maize cultivation.[11]

- Wild crop relatives will be particularly vulnerable to extinction due to climate change. A study of wild plant species related to food crops estimates that 16-22% of the wild relatives of cowpea, peanut and potato will become extinct by 2055 and the geographic range of the remaining wild species will be reduced by more than half.[12] Crop wild relatives are a vital source of resistance genes for future crop improvement, but their habitat is threatened and only a small percentage of these species is held in gene bank collections.

- Over a much longer time scale, 2070-2100, climate models predict extreme climatic changes and unthinkable projections for food security. During the last three decades of this century, the mean temperature in many of the world's poorest countries will surpass what the same countries experienced as the most extreme warm temperatures between 1900-2000. In other words, models predict that the coolest temperatures experienced during growing seasons in 2070-2100 will be warmer than the hottest growing seasons observed over the past century. In India, for example, between 1900-2000 the mean growing season temperatures hovered between 26 and 28º C; between 2070-2100 the mean growing season temperatures are projected to be approximately 29-30º in India. In Kenya, the mean growing season temperatures in the last century were approximately 21-22º C; climate scientists predict Kenya's mean growing season temperatures at the end of this century (2070-2100) will hover around 23-25º C.[13]

In a world where both biodiversity and the livelihoods of traditional farming communities are under siege, big questions loom. Will traditional farming communities, including plant and livestock breeders, be able to to adapt quickly enough to respond to abrupt or erratic climatic change? Will germplasm and adaptive traits be accessible to farmers and public breeders in regions of the South that need them most? Who will decide?

**Terminology**

**Who are the Gene Giants?** The field is not crowded in terms of numbers of 'major player' companies. Following three decades of fast-paced mergers and acquisitions, just six "Gene Giants" dominate the market for genetically engineered seed and/or the agrochemicals they depend on: Bayer, Syngenta, BASF, Dow, DuPont (Pioneer) and Monsanto.

## Hot Pursuit: The Corporate Grab on Climate-Proof Genes and Patents

For the world's largest agrochemical and seed corporations, genetic engineering is the techno-fix of choice to combat climate change. It is a proprietary approach that seeks to expand an industrial model of agriculture, one that is largely divorced from on-the-ground social and environmental realities. Not to mention, it is an approach that fails to learn from history. Many current problems with saline soils and soil degradation, for example, were exacerbated by the use of intensive production systems. Nonetheless, the Gene Giants are now focusing on the identification and patenting of "climate-proof" genetic traits associated with resistence to abiotic stresses. (Abiotic stresses are environmental stresses encountered by plants, such as drought, saline soils, low nitrogen, heat, cold, chilling, freezing, nutrient levels, high light intensity, ozone and anaerobic stresses.) These traits will theoretically enable plants to withstand environmental stresses associated with climate change.

> *"Farmers around the world are going to pay hundreds of millions of dollars to technology providers in order to have this feature [drought-tolerant maize]*."
> Michael Mack, CEO, Syngenta, 21 April 2010[14]

In a survey in 2008, ETC Group identified 532 patent documents (both applications and issued patents) filed at patent offices around the world on stress tolerant genes and traits, dubbed "climate-ready" crops. These patents, grouped into 55 "patent families" were largely applied for and/or granted to BASF, Monsanto, Bayer, Syngenta, DuPont and their biotech partners. In particular, Monsanto and BASF initially emerged as responsible for almost half of the patent filings (49%). This is significant because Monsanto and BASF announced in March 2007 that they would enter a $1.5 billion partnership to develop crops that are more tolerant to adverse environmental conditions. Although Ceres, Inc. and Mendel Biotechnology are independent companies, both conduct joint research with Monsanto (and Monsanto holds an equity stake in both). When the patent families held by Ceres (4) and Mendel (3) are added to Monsanto and BASF's total, this consortium of research partners accounted for 62% patent families identified. The following two years (June 30, 2008 to June 30, 2010) saw a dramatic upsurge in the number of published patents and patent applications related to climate-ready, genetically engineered crops. A new search in October 2010 yielded **261 patent families, which include 1663 patent documents.**

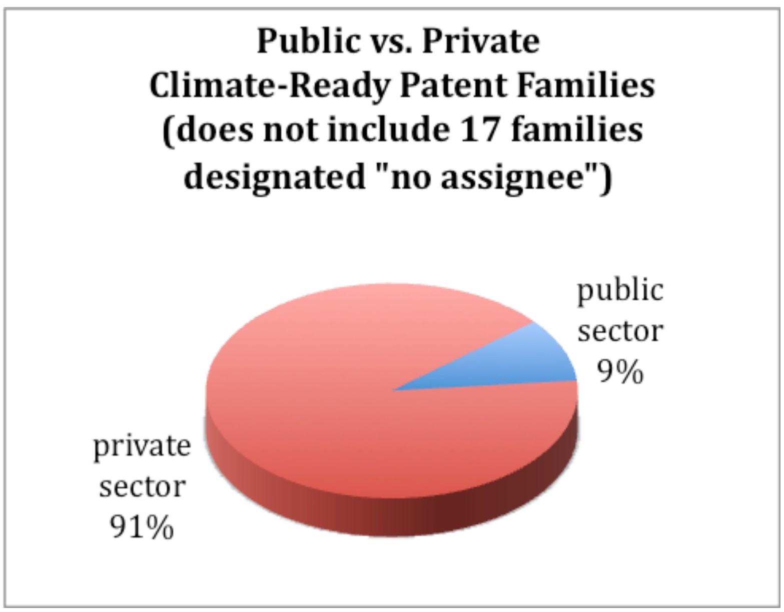
> **Terminology**
> A **patent** is a government-granted monopoly on a product (including a technology or process) that the patent applicant claims to have invented. A patent owner has exclusive legal rights to the "invention" for a specified length of time, which, in most cases, is 20 years. A **patent family** contains a set of related applied for and/or issued patents that are published in more than one country or patent office (including national and regional patent jurisdictions). All issued patents and applications that belong to the same family have the same inventor and refer to the same "invention."

**Note:** Numbers are constantly changing as government patent offices publish new patent applications and grant new patents on a daily basis. Our first study examined patent applications and issued patents published before June 30, 2008, while the second study looked at those published from that date until June 30, 2010. Our patent search identifies both patent applications and issued patents with claims that specifically mention genes and technologies related to abiotic stress tolerance in plants. However, our search is not exhaustive, and it is likely that some relevant patents/applications have been overlooked.

ETC Group's most recent survey contains a list of all the 261 patent families identified and is available online at www.etcgroup.org/en/node/5221. Here is the breakdown, which does not include the patent families for which "no assignee" is designated:

**20 public sector institutions hold 23 patent families (9%).** Includes public sector assignees based in Argentina, Belgium, Canada, China, France, Germany, Netherlands, India, Israel, South Africa, Taiwan, USA.

**26 private sector assignees hold 222 patent families (91%) Corporate Control: The major companies and their biotech partners account for over three-quarters (201 or 77%) of the patent families (both issued patents and applications).[15] Just three companies (DuPont, BASF, Monsanto) account for two-thirds (173, or 66%).** As in 2008, a small group of transnational agrochemical/seed corporations are the major players in climate ready gene patents. The companies appear to have different strategies for developing climate-ready traits in plants. For example, DuPont holds many patents that make broad claims for generic-sounding "abiotic stress tolerance" in maize and soybean cultivars (in almost all cases these claims include both conventionally-bred and transgenic varieties), while BASF, Monsanto and their biotech partners are more likely to claim gene sequences that are found across multiple plant genomes and confer some type of abiotic stress tolerance (usually multiple stresses) in transgenic plants. While Bayer and Dow (among others) are pursuing a chemical-intensive strategy (not surprisingly), claiming increased abiotic stress tolerance in transgenic plants treated with proprietary chemical/s (usually fungicides). The following chart breaks down the climate-ready patent claims by assignee (legal owner of the patent).



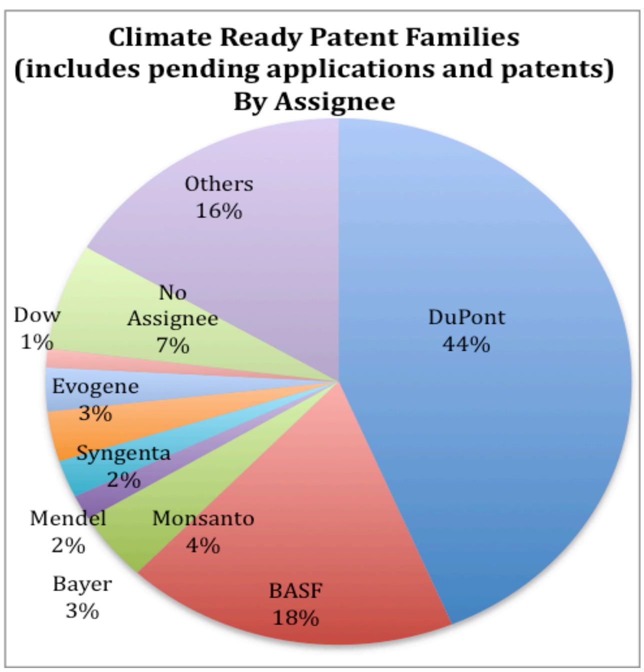
## Climate-Ready Patent Claims

**Patents and Applications Represented by 261**

**Patent Families (includes 1663 patent documents)**

**June 30, 2008 - June 30, 2010**

| **Assignee** | **# of patent families** | **% of total** | **total # patents & appli-cations in family(ies)** | **# of issued patents within family** |
|---|---|---|---|---|
| **DuPont** | 114 | 44% | 240 | 104 |
| **BASF** (includes CropDesign; Metanomics) | 48 | 18% | 522 | 53 |
| **Monsanto** (collaborates w/ BASF) | 11 | 4% | 122 | 3 |
| **Mendel Biotechnology** (partners w/ Monsanto and others) | 4 | 2% | 232 | 21 |
| **Syngenta** | 6 | 2% | 39 | 2 |
| **Evogene** (partners w/Bayer; Monsanto Dupont; Limagrain) | 8 | 3% | 64 | 1 |
| **Bayer** | 7 | 3% | 43 | 2 |
| **Dow** | 3 | 1% | 18 | 1 |
| No Assignee | 17 | 7% | 99 | 5 |
| Total Others | 43 | 16% | 272 | 28 |
| **TOTAL** | 261 | 100% | 1663 | 221 |



## The Biotech Industry's New Hand?

Patent filings cannot predict the commercial viability of a technology, but they do show where companies are investing considerable time, scientific R&D and money. The vast majority of patent claims awarded or filed in the past few years indicate that this is a relatively new area of R&D for the world's major seed and agrochemical corporations.

After failing to convince an unwilling public to accept genetically engineered foods, biotech companies see a silver lining in climate change: an opportunity to assert that genetic engineering in agriculture is necessary to win the war against climate change. In other words, industry claims that biotech crops will offer essential adaptation measures. In the words of Keith Jones of CropLife International (industry-supported non-profit organization), "GM foods are exactly the technology that may be necessary to counter the effects of global warming."[16] In reference to his company's quest to develop drought-tolerant maize, DuPont spokesman Pat Arthur told *Scientific American*: "This is a more consumer-friendly [biotech] trait than some of the others that have come out."[17]

In late 2007, 130 scientists from 12 countries gathered in Australia for the "Genomics of Drought Symposium." According to information shared at the meeting, some 50 genes have been reported to confer drought tolerance when manipulated to "over-express" in transgenic plants.[18] Monsanto, Bayer, Syngenta, Dow, BASF and DuPont all have extensive research programs in transgenic drought tolerance, focusing on major crop commodities (especially maize, soybeans, wheat) in temperate zones. The "climate correcting" genes will be sold in genetically engineered varieties that contain a growing number of "stacked traits," all of which will be subject to monopoly patent claims. The propagation of climate-tolerant varieties containing multiple proprietary genes will mean higher seed prices as well as added biosafety risks.

In a further bid to win moral legitimacy for their controversial GM seeds, the Gene Giants are also teaming up with philanthro-capitalists to develop climate-tolerant traits for the developing world. Monsanto and BASF, for instance, are working with the International Maize and Wheat Improvement Center (CIMMYT) and national agricultural research programs of Kenya, Uganda, Tanzania and South Africa to develop drought-tolerant maize. The program is supported by a $47 million grant from the Bill & Melinda Gates Foundation. Monsanto and BASF have agreed to donate royalty-free drought-tolerant transgenes to the African researchers.[19]


## How Do Climate Ready Crops Purportedly Work?

**Functional Genomics Approach:** The conventional plant breeding approach relies on crop diversity from farmers' fields, often retrieved from gene bank collections. Breeders in search of drought tolerance, for example, would begin by studying crop varieties that have a proven track record of surviving water-scarce conditions. But rather than using time-consuming tools of conventional plant breeding and the "germplasm dependent" approach, genetic engineers are now turning to functional genomics, an approach that depends on computational "gene prediction" platforms to rapidly identify climate-related genes and traits.

Genomics information, robotics, and massive computer power now make it possible to pinpoint genes of interest in a model plant and then identify similar genetic sequences in the crop of interest. Rather than transferring genes from one plant to another, scientists are learning how to identify key gene sequences and then over-express a plant's own genes to achieve a desired result.

**Terminology**

The term **gene** refers to the physical and functional unit of heredity. A gene is an ordered sequence of nucleotides located in a particular position on a particular chromosome (and can exist in a series of alternative forms called alleles) that encode a specific functional product (i.e., a protein or RNA molecule). However, the correlation between a *trait* and a *gene* is complex. The combination of genes is one important determinant for the development of a plant's traits. Most plant traits are governed by more than one gene.

Traits associated with abiotic stresses are complex and determined by multiple genes. Scientists trying to identify a particular region of the genome that is associated with the plant's physical form or traits do so by using information gleaned from research on model plants such as *Arabidopsis thaliana*.

*Arabidopsis thaliana,* a flowering mustard plant, is the lab-rat of plant molecular biology and its molecular make-up has been studied more than any other plant. *Arabidopsis* is considered a model organism because it has a small genome, short life cycle, prolific seed production and it is relatively easy to engineer.[20] In December 2000, *Arabidopsis's* genome was the first plant genome to be fully sequenced (and placed in the public domain). Researchers predict they will soon decipher the function of the plant's 25,000+ genes.[21] The goal is to build a "virtual plant" based on the *Arabidopsis* genome – a computer model that will allow researchers to simulate the growth and development of a plant under any environmental conditions. Researchers believe that the knowledge gained from *Arabidopsis* will explain the genetic behavior of other plant species.

**Transcription Factors:** Transcription factors refer to a class of genes that control the degree to which other genes in a cell are activated. Transcription factors are able to recognize and bind to regions of DNA that have a specific sequence in the promoters of the genes they regulate. If a dozen genes all have that region of DNA somewhere in their promoters, they will all be regulated by the same transcription factor. Mendel Biotechnology explains why transcription factors are important: "Because transcription factors are key controlling elements of biological pathways, altering the expression levels of one or more transcription factors can change entire biological pathways in an organism."[22] In some cases, genetic engineers are also attempting to control the timing, tissue-specificity and expression level of the introduced genes for optimal performance. This is important if the stress resistance is to be triggered only at a specific time, in a specific part of the plant, or under specific stress conditions.

Stress responses such as drought tolerance involve coordinated changes in many genes. The ability to effect many changes with one gene is an attractive proposition. Genetic engineers are using transcription factors to activate cascades of genes that function together to enhance stress tolerance, which is why many researchers are focusing on transcription factors in *Arabidopsis.* Not surprisingly, many of the patents related to transgenic stress tolerance involve transcription factors.

**Stress-induced proteins:** While transcription factors are a major focus of current research on transgenic stress tolerance, it's not the only approach. Patent claims reveal that researchers are also focusing on genes that code for single enzymes, ion transport proteins, or other functional proteins that affect a plant's biological pathway. Some genes code for proteins that are key enzymes in biochemical pathways; when these proteins are over-expressed, the products downstream in the pathway are likely to increase as well.

For example, the plant hormone ABA (abscisic acid) is important for stress response. By over-expressing a key enzyme for the synthesis of ABA, the level of ABA can be increased and then this hormone can regulate a number of other genes. Ceres holds patents on a gene-encoding enzyme required to make ABA.[23]

Monsanto holds several patents on key enzymes that increase antioxidants, such as tocopherol (vitamin E is an example), which have been shown to protect plants against stress.[24] The genes were identified by screening for tocopherol levels in mutated *Arabidopsis* plants.

**Designer DNA for Climate-Ready Crops?** Using biotech to "fix" climate change is just one approach in the high-tech tool kit. Extreme genetic engineering – inspired by molecular biology, computing and engineering – is not far behind. In April 2010, synthetic biologists from the Weizmann Institute (Israel) described their initial efforts to increase crop yields by boosting the rate of carbon fixation in plants (a metabolic process in living cells that converts carbon dioxide into biologically-useful molecules).[25] The scientists honed in on 5,000 metabolically-active enzymes that are known to catalyze the process of nitrogen fixation in nature. Using mathematical models, they predicted new, faster biochemical pathways for improving the rate of carbon fixation, concluding that, "proposed synthetic pathways could have significant quantitative advantages over their natural counterparts." Synthetic biologists acknowledge that the leap from computer models to real-world applications in living plants is a daunting challenge, but they remain techno-optimists: "Our findings suggest exciting avenues of exploration in the grand challenge of enhancing food and renewable fuel production via metabolic engineering and synthetic biology."[26] The scientists have applied for patents on synthetic pathways related to carbon fixation.[27]

## Corporate R&D Related to Genetically Engineered Climate Tolerant Genes

All of the world's largest seed and agrochemical companies support research on drought and heat tolerant genes or other genetic traits for withstanding environmental stresses. The target crops are primarily transgenic wheat, maize, and soybeans for temperate regions. Not limiting themselves to food and feed crops, the major players also support research related to biofuels and industrial feedstocks (biomass). A profile of projects underway reveals a tangled web of partnerships between Gene Giants and between Gene Giants and their smaller biotech partners.

DuPont (under the name Pioneer Hi-Bred International, Inc.) hopes to have a drought-resistant maize on the market by 2012. It refers to its work on drought tolerance technologies as "the next great wave of agricultural innovation."[28] Pioneer's vice-president for biotech and regulatory affairs, Jeffrey Rowe, points out that, unlike the company's major competitors, Pioneer started off as a seed company (later acquired by DuPont) and has been conducting research on drought-tolerant maize for the past 60 years.[29] "We have such a rich base of proprietary germplasm – other companies wouldn't have nearly the richness in germplasm," explains Rowe. Although the company was initially skeptical about drought tolerance, Rowe admits, "what you're seeing now is a continuing and growing sense of confidence that what we have is real. We continue to grow in confidence in this trait [drought tolerance]."[30] According to DuPont spokesman Bill Niebur, "We've got our top talent in our organization working on this."[31]

The company operates two 200-acre research stations (in California and in an arid region of Chile) and thousands of test plots dedicated solely to drought research.[32] DuPont has a joint venture with Chinese biotech company Beijing Weiming Kaituo to develop genetic traits such as stress tolerance and nutrient utilization for maize and rice. At the end of 2007, DuPont announced a new collaboration with Evogene Ltd. (Israel) that will give DuPont exclusive rights to several drought-resistant genes discovered by Evogene in maize and soybeans.[33] The genes were identified by Evogene's proprietary *in silico* "gene discovery technology" called "ATHLETE."[34] (*In silico*, as opposed to *in vivo* or *in vitro*, refers to investigations performed through the use of a computer or computer simulation.)

Athlete is the company's proprietary computer database and analysis program for identifying gene function. It does this by comparing sequences from as many different plant species, tissues, organs, and growth conditions as possible. In 2008, Evogene claimed its database consisted of 8 million expressed sequences, 400,000 "proprietary gene clusters," and 30 plant species. In August 2010, Evogene revealed Athlete 3.0, which expanded Evogene's genomic data to over 130 plant species.[35] Evogene's website describes the platform it uses to identify key genes: "Athlete uses vast amounts of available genomic data (mostly public) to rapidly reach a reliable limited list of candidate key genes with high relevance to a target trait of choice. Allegorically, the Athlete platform could be viewed as a 'machine' that is able to choose 50-100 lottery tickets from amongst hundreds of thousands of tickets, with the high likelihood that the winning ticket will be included among them."[36]

In an informed winnowing process, the program clusters sequences according to a variety of criteria and then determines which gene candidates to investigate further. Identified sequences are then synthesized, cloned, and used to engineer model plants such as *Arabidopsis* and tomato for validation of function. If the over-expressed sequence results in the desired trait in *Arabidopsis*, then Evogene predicts that the homologous sequence in a crop plant will do the same. Claiming to hold over 1,500 novel genes for key plant traits, the company boasts that it can discover novel genes, test them in model plants, and move them to crops, all in-house. Pioneer has licensed exclusive rights to certain genes discovered by Evogene.

## Terminology

**"Biomass"** refers to material derived from living or recently-living biological organisms: including all plants and trees, microbes, as well as by-products such as organic waste from livestock, food processing and garbage. ETC Group's report, *The New Biomassters*, warns that the bio-economy will facilitate a corporate grab on all plant matter and the destruction of biodiversity on a massive scale. With extreme genetic engineering, the world's largest corporations are poised to manufacture industrial compounds – fuel, food, energy, plastics and more – using biomass as the critical feedstock. Invoking climate change and in the name of moving "beyond petroleum," the "Biomassters" are poised to appropriate and further commodify plant matter in every part of the globe.

Evogene also collaborates with Monsanto. A deal struck between the two companies gives Monsanto exclusive rights to a number of genes identified by Evogene that reportedly allow crops to maintain stable yields with lower applications of nitrogen.[37] The companies also collaborate on drought tolerance.

In 2007, BASF and Monsanto initiated the world's largest agricultural research collaboration, jointly investing $1.5 billion to develop stress-tolerant maize (corn), soybean, cotton and canola.[38] Considering these four crops account for virtually all the commercial GM plants, the focus the biggest joint biotech R&D program on record is not surprising.[39] In July 2010, BASF and Monsanto announced an additional investment of $1 billion to extend to abiotic stress tolerance tests to wheat, the world's second most valuable crop commodity after maize.[40] To punctuate the deal, Monsanto announced in August 2010 that it would acquire a 20% stake in Australia's largest wheat-breeder, the state-owned Intergrain. The equity stake gives Monsanto "a vast new library of germplasm."[41]

In addition to in-house R&D, Monsanto farms out gene and trait discovery to companies like Ceres and Mendel. Ceres's website claims that it holds "the world's largest collection of plant gene intellectual property" and is Monsanto's "largest external supplier of plant biotechnology."[42] Drought tolerance is just one of the traits in its pipeline.[43]

Monsanto has been testing drought-tolerant genes in South America for several years. In 2007, the company reportedly identified at least 800 genes offering drought-tolerance and improved yields.[44] "More than we would have thought," remarked Rob Fraley, Monsanto's chief technology officer.[45] Monsanto and BASF claim that the world's first-ever genetically engineered, drought-tolerant maize variety will be the opening product to emerge from their joint pipeline, scheduled for commercial release around 2012. The companies claim that field tests of drought-tolerant maize in drought-prone areas of the USA's western Great Plains "met or exceeded" expectations – with yield increases of about 7 to 10% over average yields.[46] Monsanto also is engineering drought-tolerant cotton, wheat and sugar cane.

In January 2010, BASF announced a new collaboration with KWS (Germany-based, top 10 seed company) to develop sugar beets with improved drought tolerance and 15% higher yield. Agrofuels, including genetically modified trees, are a big target: BASF also collaborates with Brazil's Centro de Tecnologia Canavieira (CTC) to develop sugarcane with improved drought tolerance and 25% higher yield.[47]

Mendel Biotechnology is a major player in climate-ready crop genes. Mendel holds patents on key genetic engineering methods for drought-tolerant maize and soybeans, and boasts that it was the first company to develop drought-tolerant technologies for plants.[48] Mendel focuses on transcription factors. According to Mendel scientists, the 25,000+ genes in the *Arabidopsis* genome are controlled by about 1,800 different transcription factors. By analyzing the function of all *Arabidopsis* transcription factors, Mendel scientists claim that single transcription factors can control complex traits such as the ability of plants to withstand freezing, drought, or disease, to use nitrogen efficiently, and other complex traits. The company holds a number of exclusive monopoly patents on specific transcriptional factors related to abiotic stresses such as drought.

According to Mendel's website, Monsanto is the "most important customer and collaborator for our technology business." Mendel has been collaborating with Monsanto since 1997. Under the terms of the current agreement, Monsanto has **exclusive** royalty-bearing licenses to Mendel technology in certain large-acreage crops and vegetables. Mendel's other big partners are BP and Bayer. Mendel is working with Bayer to develop chemical products that regulate plant stress tolerance. Since 2007, Mendel has been collaborating with BP on second-generation biofuels. The focus of the collaboration is the development and commercialization of dedicated energy crops such as *Miscanthus* and switchgrass. Mendel also works with Arborgen on genetically engineered trees.

Arcadia Biosciences (Davis, California), founded in 2002, is collaborating with some of the world's largest seed companies to develop genetically engineered, stress-tolerant crops. Although Arcadia is privately held, BASF's venture capital fund has invested in the company since 2005. In 2009, Vilmorin (owned by Groupe Limagrain, the world's 4th largest seed company) and Arcadia entered into a partnership for the development of nitrogen-use efficiency in wheat. In May 2010, Vilmorin announced an equity investment in Arcadia (7.25%). Arcadia has agreements with Monsanto, DuPont, Vilmorin, Advanta (India) and the US Agency for International Development (USAID) on projects related to nitrogen-use efficiency, drought and salinity tolerance. (The company has licensed the use of its nitrogen-use efficiency technology for genetically engineered crops at least 40 times, for virtually all major crops "in most countries of the world."[49])

Arcadia is also pursuing drought tolerance. In January 2008, Arcadia announced that it had successfully completed its first field trial for genetically engineered drought-tolerant tobacco. (Tobacco is commonly used as an experimental crop.) The company claims that its drought-tolerant crops could be commercially available by 2016. The technology was developed by an international research team, led by the

University of California-Davis, which has applied for patents on the gene technology.[50] Drought-tolerance was achieved by inserting a gene into the tobacco plants to interrupt the biochemical chain of events that normally leads to the loss of the plant's leaves during water shortage.[51] By genetically suppressing the death of leaf cells, the plants are theoretically better equipped to survive drought and sustain yields.[52]

In April 2008, Arcadia Biosciences announced a multi-crop research and commercial license agreement with Mahyco in India for Arcadia's nitrogen use efficiency and salt tolerance technologies. Mahyco is India's largest private seed company and has a 50/50 joint venture with Monsanto (Mahyco Monsanto Biotech Ltd.) to market transgenic seeds in India. According to Mahyco spokesman Usha Zehr, "Nitrogen use efficiency will bring great benefits to Indian farmers by providing better yield under existing conditions or leading to lowering of nitrogen fertilizer applications in some areas and still maintaining yields."[53]

Syngenta is developing "water optimization technology" for maize that is designed to thrive in both excessive and limited rainfall. The leader of Syngenta's North American maize breeding program told *Farm Industry News*: "What we are developing is drought genes that will enable plants to make better use of water, eliminating or reducing yield reduction caused by variable water conditions."[54] It unveiled its first generation drought-tolerant maize ("water optimized hybrids") in July 2010. The company's "Agrisure Artesian Technology" is the result of conventional (non-transgenic) breeding. According to Syngenta, the product, to be sold in the US western Corn Belt region, offers the "potential to deliver 15% yield preservation under drought stress." The company claims it is the first to market "an abiotic stress solution to help growers deal with drought conditions."[55] Syngenta predicts that its second-generation maize hybrids – genetically engineered for drought tolerance – will be available post-2015, pending regulatory and import market approvals.[56]

Dow Agrosciences, focusing primarily on fertilizer efficiency, is pursuing a different strategy. The World Business Council for Sustainable Development (WBCSD – "the leading business voice at climate negotiations") showcases Dow's new technologies for "tackling climate change on the ground."[57] Dow claims that two of its new products, N-Serve® nitrogen stabilizer and Instinct™ nitrogen stabilizer, will help reduce fertilizer-induced greenhouse gas emissions. The products control the bacteria that convert nitrogen during nitrification, reportedly decreasing the amount of wasted nitrates that enter the atmosphere or leach into groundwater and waterways.

## Biotech Carbon Credits and Corporate Subsidies for Climate Friendly Crops

**There** are two biotech companies hoping to exploit carbon credit schemes in order to win new markets for crops engineered with so-called climate-ready genes. In China, US-based Arcadia Biosciences, for example, is working with government authorities in the Ningxia Hui Autonomous Region to develop a carbon credit methodology whereby farmers planting the company's genetically engineered rice can earn carbon credits.[58] The company claims that its GM rice will require less fertilizer as it is engineered to absorb nitrogen fertilizer more efficiently. Chemical fertilizers are a major contributor to global greenhouse emissions. Arcadia's GM rice has not received regulatory approval and is not yet commercially available. If the Clean Development Mechanism of the UN Framework Convention on Climate Change (UNFCCC) can be convinced that GM crops are "green" and climate friendly, carbon credits for rice farmers will create a demand for genetically engineered seeds and a bonanza for the biotech industry. Arcadia's president Eric Rey (formerly an executive of Calgene, now owned by Monsanto) explains that "it's a way for farmers, and us, to make money, while doing something positive to help the environment."[59] To date, global carbon markets do not award credits for GM crops. Although the company has not yet developed an approved methodology to substantiate that its genetically engineered crops reduce emissions, Rey says there is “huge momentum” to develop carbon credits for agriculture, especially in the United States.[60]

Monsanto is also hoping to cash in on carbon credit trading schemes for farmers who grow the company’s GM crops. Monsanto claims that its “Roundup Ready” crops – plants engineered to withstand the spraying of its proprietary weed killer (brand-name Roundup) – promote the use of conservation tillage by reducing the need to till the soil to achieve weed control.[61]

The US government’s Federal Crop Insurance Company began its Biotech Yield Endorsement (BYE) pilot program in 2008, offering a discount to farmers planting Monsanto’s “triple-stack” maize seeds on non-irrigated land – because the biotech maize engineered for herbicide tolerance and two kinds of insect resistance reportedly provides lower risk of reduced yields when compared to conventional hybrids.[62] (Monsanto’s own data were used to substantiate this claim.)

Genetically engineered climate-hardy crops will undoubtedly sell for top dollar. Farmers in the United States already pay premium prices for biotech seeds that are loaded with up to three genetic traits. For example, in 2008, Monsanto’s “triple-stacked” biotech maize seed sold for about $245 per bag. Conventional maize seeds sold for $100 per bag.[63]

Market-based carbon trading schemes for GM crops, as well as the US government’s corporate seed subsidy for Monsanto’s maize, raises a host of concerns. Will governments someday require farmers to adopt prescribed biotech traits? Will climate change lead to a “state of technological emergency” in which corporations are given *carte blanche* to disseminate proprietary genetic technologies?

## Patent Grabbing Strategies: Multi-Genomes and Multi-Sequences

The genomics approach is especially attractive to Gene Giants because it gives them an opportunity to make sweeping patent claims that extend far beyond a single crop and often include multiple stresses. Many of the patents claim isolated DNA sequences that are associated with abiotic stress tolerant traits. Because of the similarity in DNA sequences between individuals of the same species or among different species – “homologous sequences” – **the patent claims extend not just to abiotic stress tolerance in a single engineered plant species, but also to a substantially similar genetic sequence in virtually all transformed plants.** The claims typically include any gene or protein with “substantial identity” that is associated with abiotic stress tolerance in transgenic plants, as well as methods for using the isolated gene sequences to engineer the plant to respond to abiotic stress.

For example, **DuPont’s** (Pioneer Hi-Bred) November 2007 patent for “transcriptional activators involved in abiotic stress tolerance” claims a method for expressing the genetic sequences in a plant that improves its cold and/or drought tolerance (US Patent No. 7,253,000, patent family 45). The claims are not limited to drought/cold tolerance in a single crop, but to use of the technology in transgenic monocots (maize, barley, wheat, oat, rye, sorghum or rice) and dicots (soybean, alfalfa, safflower, tobacco, sunflower, cotton or canola). Monocots and dicots are the primary classes of flowering plants. Nearly all of the world’s food supply comes from flowering plants.

Many of **BASF’s** patents are similarly broad in scope. For example, US Patent No. 7,161,063 (patent family 6, Appendix A) claims a specified polynucleotide sequence associated with increased tolerance to environmental stress found in any transgenic plant cell from monocot or dicot plants – including a whole plant, a plant cell, a plant part or a plant seed. To reinforce the multi-genome claim, the patent specifically identifies the expressed gene in the following plants: “maize, wheat, rye, oat, triticale, rice, barley, soybean, peanut, cotton, rapeseed, canola, manihot, pepper, sunflower, tagetes, solanaceous plants, potato, tobacco, eggplant, tomato, *Vicia* species, pea, alfalfa, coffee, cacao, tea, *Salix* species, oil palm, coconut, perennial grass and a forage crop plant."[64] In other words, virtually all food crops. The isolated polynucleotide sequence is also claimed when it is used as a vector for transforming plants.

A **Syngenta** (Switzerland) patent application also seeks extremely broad claims. US patent application US20060075523A1 (patent family 47) claims gene sequences that confer abiotic stress tolerance – including "cold stress, salt stress, osmotic stress or any combination thereof." The claims extend to a "substantially similar" gene sequence from a monocot or a dicot plant, from a cereal (including maize, rice, wheat, barley, oat, rye, millet, milo, triticale, orchard grass, guinea grass, sorghum and turfgrass). Also claimed are methods for using the specified gene sequences as vectors, expression cassettes, and as plants containing such polynucleotides to alter the response of a plant to abiotic stress.

The standard approach that biotech companies have been using for the past two decades is to claim any plant that has been engineered to express a proprietary gene or genes. With the current patent grab on climate genes, we're seeing even more expansive claims, which are likely to result in conflicting or overlapping claims. In recent years, the world's largest seed companies have cross-licensed agricultural technologies with one another as a strategy to avoid costly patent battles and duck anti-trust regulations.[65] Given the existing partnership between BASF and Monsanto in this area, for example, we are likely to see the largest companies cross-licensing proprietary biotech genes related to abiotic stress traits in transgenic plants.

After 8 years of mapping and sequencing the DNA of plant genomes, plenty of "code" (nucleotide bases and amino acid sequences) is up-for-grabs.[66] The genomes of thousands of living organisms have been sequenced since 1995,[67] but a relatively small fraction of those have been of land-based plants. This is due, in part, to an unexpected technical hurdle: for some domesticated crops, the size of the genome is enormous, more than five times bigger than the human genome.[68] In 2002, the first plant genome to be fully sequenced and published was *Arabidopsis thaliana*, with a small genome of ~120 megabases (Mb). The plant is widely used as a model plant in research. (Genome size is often measured in millions of base pairs [pairs of nucleotide bases], or megabases.)

In 2002, rice (*Oryza sativa*) was the second plant genome to be published, the first major crop genome to be fully sequenced and the first food crop genome. (Both subspecies of rice, *Oryza sativa japonica* and *Oryza sativa indica* have now been sequenced.) The rice genome contains about ~ 466 Mb.[69]

The rice genome quickly became the target of monopoly claims. Although the genomic information was deposited in public databases, that didn't stop it from being privatized.[70] The patent grab on key gene sequences in the world's major crops is neither trivial nor theoretical. A decade ago, genomic companies and Gene Giants were routinely filing "bulk" claims on huge numbers of DNA and amino acid sequences (i.e., protein) – over 100,000 in some cases – without specific knowledge of their function.[71]

In 2006, Australia-based Cambia, an independent non-profit that promotes transparency in intellectual property, used its Patent Lens project to conduct an in-depth analysis of US patents and patent applications that make claims on the rice genome.[72] Patent Lens revealed that, by 2006, roughly **74%** of the rice genome (*Oryza sativa*) was named in US patent application claims – due, in large part, to bulk sequence applications. They discovered that **every** segment of the rice genome's 12 chromosomes was cited in patent applications, including many overlapping claims. A remarkable graphic display is available here: www.patentlens.net/daisy/RiceGenome/3909/2865.html

No surprise as to who are the key players in rice genome patent claims: DuPont, Monsanto, Syngenta, BASF, Bayer.[73] Fortunately, Cambia's 2006 analysis concluded that the corporate quest to win monopoly patents on molecular-level chunks of the world's most important food crop had only partially succeeded – *so far* – and that most of the rice genome remains in the public domain. That's due, in part, to recent decisions (by courts and patent offices) that attempt to restrict the number of DNA sequences that can be claimed in a single patent application. Cambia's Patent Lens is currently updating its patent landscape on rice and plans to provide a patent landscape for other major crops as well.

## New Rulings Attempt to Curb Monopoly Claims on DNA Sequences

In 2001 the US PTO put a brake on "bulk claims" by issuing new guidelines requiring that claimed inventions must have "well-established" utility (a standard patent criterion).[74] In 2007, the US PTO took another step away from bulk claims on gene sequences by issuing a notice that gave patent examiners the option of restricting claims to only a single nucleotide sequence in each application (although the examiner has the option of examining more than one sequence if s/he deems it appropriate.).[75] As a result of these changes, US patent examiners are less likely to grant patents on more than a few DNA sequences at one time.

In July 2010, Europe's highest court – the European Court of Justice (ECJ) – made a ruling that significantly restricts the reach of agricultural biotech patents on DNA sequences, specifically reigning in the breadth of Monsanto's monopoly on herbicide tolerant soybeans.[76] (The ECJ's decision was based on Monsanto's lawsuit against Dutch importers of soy meal from Argentina that contains patented DNA.[77] Monsanto's herbicide-tolerant soybean is widely grown in Argentina but the company doesn't receive royalties there because Monsanto's patents aren't recognized under Argentine law. Hoping for downstream rewards, Monsanto charged that European importers of Argentine soy meal were infringing the company's patent because Monsanto's patented DNA was present in the imported soy.)

The Court's decision makes clear that claims on DNA sequences will *not* extend to derivative or processed products, even if the patented DNA sequence is still present in those products.[78] The European Court affirmed that the purpose (function) of the DNA sequence must be disclosed in the patent, and protection of the sequence is limited to those situations in which the DNA is performing the function for which it was originally patented.

**Recent rulings to restrict monopoly claims on DNA sequences are significant, and a major upset for Monsanto, but that hasn't stopped the scramble for gene-based patents.** In the words of one patent lawyer, "The challenge for patentees in this area will be to find alternative ways to protect these products."[79]

Patent Lens points out that patent lawyers routinely use tricks of the trade to broaden the scope of claims beyond the actual DNA sequences that are specified. Companies are broadening claims by using highly complex and technical language that is designed to capture multiple gene sequences and/or amino acids that code for proteins. Patent Lens provides specific examples of broadening language here: www.patentlens.net/daisy/RiceGenome/3660/3609.html#dsy3609_specify

For example, a company may dramatically broaden the scope of its claim by using "percent identity language." The claim includes not only the sequence of interest, but any sequence that is, for example, 70, 80, or 90% identical to that sequence. According to Patent Lens, this technique "dramatically broadens the scope of the claim" by increasing the number of individual sequences that meet the criteria of the claim.

Another strategy for broadening language, according to Patent Lens, is to provide the sequence identification number (SEQ ID NO) of an amino acid and word the claim so that any nucleotide sequence that encodes that amino acid sequence is also claimed.[80] Nucleotide and/or amino acid sequences as defined by the US Patent and Trademark Office consist of "an unbranched sequence of four or more amino acids or an unbranched sequence of ten or more nucleotides."[81] (Note: Patent applications which disclose nucleotide or amino acid sequences disclose them in a section entitled "Sequence

Listing," and each sequence is assigned a separate Sequence Identification Number. By international treaty, other major patent offices use substantially the same system.)

Although some of the most egregious examples of sweeping patent claims identified by ETC Group are found in patent applications that have not yet been issued, there's plenty of reason to be concerned. According to Patent Lens, applications alone may be used to scare off potential infringers, or used as leverage in licensing negotiations.[82] Because of "provisional patent rights," even a patent that has not yet been issued can be a significant deterrent to competitors. In the United States and some other countries, the patent holder may be able to demand royalties from someone who uses the subject matter of a patent application if the patent is later granted. Notes Patent Lens, if "the claims in the granted patent are substantially identical to the claims in the application, the patentee has the option to collect royalties retroactively to the publication date of the patent." In other words, the mere existence of the designation "patent pending" is a powerful deterrent that may discourage others from using, making or selling a technology that is claimed in a patent application.[83]

**Patent applications – why worry?** It's not unusual for Gene Giants to seek the broadest possible claims for their "inventions." Some people caution that it is premature to worry about over-reaching applications because patent attorneys typically "claim the moon," only to scale back later by modifying the initial application if patent examiners reject portions of the original claims. This may be true in some cases, but there is still plenty of reason for concern. Corporate patent attorneys are handsomely rewarded to stake sweeping claims that capture the broadest monopoly possible. And they often succeed. Once a patent is granted, most patent regimes favor the rights of the patent holder, not the public good. ETC Group recalls that it took 13 years to defeat Monsanto's European Patent on ALL genetically modified soybeans![84] It took more than a decade (half the term of the patent) to defeat an unjust US patent on Mexico's yellow bean.[85] Any patent regime that takes over a decade to correct an obvious wrong is broken beyond repair and can hardly be considered "self-correcting." Despite recent rulings limiting, in some cases, the patenting of gene sequences, the practice of over-reaching patent claims and unjust monopolies is far from over.

## Examples of Patents and Patent Applications on So-Called Climate-Ready Genes and Technologies

**In February 2010, Mendel Biotechnology (USA) won US patent 7,663,025 "Plant Transcriptional Regulators," a monopoly that includes 224 patent family members.** In other words, Mendel has applied for or been granted patents on the same "invention" (including different steps in the application process) 224 times. This includes foreign filings: the European Patent Office (EPO), the World Intellectual Property Organization (WIPO), and at national patent offices in Mexico, Brazil, Australia, Canada, Japan and South Africa. Mendel obviously considers its technology a key "invention" and has already shelled out millions of dollars on patent fees. The patent claims transcriptional regulators[86] (a class of genes that control the degree to which other genes in a cell are activated) that reportedly confer improved stress tolerance in genetically engineered plants – not for a single abiotic stress, but for increased tolerance to drought, shade, and low nitrogen conditions. The claims extend far beyond a single plant species to virtually any transgenic plant and seed that expresses the DNA sequence encoding a specified DNA sequence: "any transgenic plant that comprises a recombinant polynucleotide encoding SEQ ID NO: 8."

*Claim 8. A transgenic plant that comprises a recombinant polynucleotide encoding SEQ ID NO.*

*Claim 9. The transgenic plant of claim 8, wherein expression of SEQ ID NO: 8 in the transgenic plant confers to the transgenic plant increased tolerance to hyperosmotic stress, drought, low nitrogen conditions or cold, as compared to a control plant.*

*Claim 10. A transgenic seed produced from the transgenic plant of claim 8.*

**BASF holds** US Patent 7,619,137 entitled "Transcription factor stress-related proteins and methods of use in plants," which contains 55 family members. The patent lays claim to increased tolerance to environmental stress including salinity, drought and temperature. The claims extend to transgenic plants transformed with isolated DNA sequences that confer increased tolerance to environmental stress, as compared to a wild type variety of the plant. The claims extend to virtually all flowering plants – transgenic plants that are either monocots or dicots – including maize, wheat, rye, oat, triticale, rice, barley, soybean, peanut, cotton, rapeseed, canola, manihot, pepper, sunflower, tagetes, potato, tobacco, eggplant, tomato, Vicia species, pea, alfalfa, coffee, cacao, tea, Salix species, oil palm, coconut, perennial grasses, and a forage crop plant.

Another US patent assigned to **BASF**, US Patent 7,714,190, is similar in its multi-genome claims. The patent claims extend to transgenic plants (and seeds) transformed with isolated DNA sequences that reportedly endow plants with increased tolerance to environmental stress (compared to a non-engineered variety of the plant). The claims on isolated DNA sequences that confer the increased tolerance in transgenic plants extend to multiple plant genomes: including maize, wheat, rye, oat, triticale, rice, barley, soybean, peanut, cotton, rapeseed, canola, manihot, pepper, sunflower, tagetes, solanaceous plants, potato, tobacco, eggplant, tomato, Vicia species, pea, alfalfa, coffee, cacao, tea, Salix species, oil palm, coconut, and perennial grass.

## Claims Extending to Harvested Materials:

**On 18 February 2010, WIPO published Monsanto's international patent application** (WO2010019838A2) entitled "stress tolerant transgenic crop plants." It describes novel proteins derived from bacterial cold shock proteins, which, upon expression in transgenic plants, provide the plants with enhanced stress tolerance (to heat, salt and drought). The application makes extremely broad claims, not just to the modified plant cells in soybean, corn, canola, rice, cotton, barley, oats, alfalfa, sugarcane, turf grass, cotton, and wheat that exhibit improved stress tolerance, ***but also to the processed plant product derived from the transgenic plant***, including "feed, a meal, a flour, an extract, or a homogenate, wherein said feed, meal, flour, extract, or homogenate is obtained from at least one plant part."

Monsanto's patent application is not unique in the reach of its claims. **Ceres applied for a US patent (US20090094717A1) in April 2009** for nucleotide sequences and corresponding polypeptides responsible for modifying a plant's characteristics. (Ceres has a partnership with Monsanto and several other public and private firms.) Instead of specifying abiotic stress traits, Ceres is going after the whole banana. Here is the laundry list of possible modulated characteristics claimed in its application:

*Claim 5: The method of claim 4, wherein the modulated plant growth, development or phenotype characteristics comprise a modulation in any one of plant size, plant height, plant strength, vegetative growth, color, plant architecture, amount of branching, branching angle, branching length, number or leaves per branch, organ number, organ size, organ shape, leaf shape, leaf structure, leaf size, leaf number, leaf angle, biomass, sterility, seedling lethality, seed weight, seed size, seed color, seed yield,* *seed germination, seed content, seed structure, seed carbon content, seed nitrogen content, seed fiber content, fruit composition, fruit shape, fruit size, fruit length, fruit yield, silique length, silique shape, flower length, flower shape, flower size, inflorescence length, inflorescence thickness, cotyledon size, cotyledon number, cotyledon shape, crop development or harvest time, flowering time, senescence, time to bolting, drought or stress tolerance, biotic stress tolerance, abiotic stress tolerance, tolerance to high density plant population, tolerance to high pH, tolerance to low pH, tolerance to low nitrogen conditions, tolerance to no nitrogen conditions, tolerance to high nitrogen conditions, tolerance to nutrient limiting conditions, tolerance to oxidative stress, tolerance to cold stress, tolerance to heat stress, tolerance to saltstress, chlorophyll content, photosynthetic capacity, root growth, nutrient uptake, chemical composition, anthocyanin content, starch content, nitrogen content, internode length, hypocotyls length, ability to grow in shade, and shade avoidance as compared to the corresponding characteristics of a control plant that does not comprise said nucleic acid.*

**Ceres' claims also extend to harvested food and feed products:**

*Claim 13. "A food product comprising vegetative tissue from a transgenic plant according to claim 9."*

*Claim 14. "A feed product comprising vegetative tissue from a transgenic plant according to claim 9."*

**Double-Dipping Monopoly?** A recent US patent application by **Dow Agrosciences**, US20090300980A1, makes the unusual argument that the company's genetically engineered maize plants that express an insect resistant gene *also* use nitrogen fertilizer more efficiently *and* exhibit drought tolerance. As stated in the patent, insect-resistant transgenic plants "are unexpectedly more effective at assimilating not only nitrogen but also less valuable nutrients such as phosphorous, potassium and micronutrients such as zinc."[87] Unexpectedly? Does that sound like an inventive step? The new-use-for-existing-product is striking because of its similarity to the pharmaceutical industry's strategy of claiming new uses – and therefore new patents – for existing drugs.[88]

## Patents for the Poor! Public/Private Partnerships for the Development of Climate-Ready Crops

To gain moral legitimacy, Gene Giants like Monsanto, BASF, Syngenta and DuPont are forging high-profile partnerships with public sector institutions that aim to deliver proprietary technologies to resource-poor farmers. (The strategy is not new – remember Golden Rice? – but the partnerships are proliferating.) The public/private partnerships are hosted by a growing web of South-based non-profit institutions (funded by the North) that exist primarily to facilitate and promote the introduction of genetically engineered crops. The immediate impact of these partnerships is to enhance the public image of Gene Giants as they donate royalty-free genes to needy farmers. But the longer-term goal is to create the "enabling environments" (biosafety regulations, intellectual property laws, positive media coverage to promote public acceptance) that will support the market introduction of genetically engineered crops and related technologies. It's a package deal wrapped in a philanthropic façade and it comes with strings attached. The development of abiotic stress tolerance in crops (including conventionally-bred and transgenic varieties) is a key feature of many partnerships. For example:

The Nairobi-based **African Agricultural Technology Foundation** (AATF) is one of the primary deal-brokers in the South. Launched in 2003, AATF is a non-profit organization that promotes public/private partnerships to ensure that resource-poor African farmers have royalty-free access to proprietary agricultural technologies to improve their productivity. Start-up funds were provided by the Rockefeller Foundation, the US Agency for International Development, and the UK's Department for

International Development (DFID). Two of AATF's five projects are dedicated to the development of abiotic stress tolerance in crops:

1) Water efficient maize for Africa (WEMA);

2) Rice varieties suitable for soils that are low in nitrogen, and for drought and saline tolerance.

In addition to its role as African-based broker of public/private deals, AATF aims to "continuously monitor and document the evolution of regulatory frameworks for GM crops in African countries." AATF plays a major role in promoting and facilitating regulatory frameworks by influencing public opinion in Africa and "overcoming the misconceptions about genetically modified organisms that slow down the adoption of biotechnology products." In August 2009, for example, WEMA's partners hosted a 4-day workshop on private sector confidentiality agreements (facilitated by Monsanto and CGIAR's Advisory Services on Intellectual Property). At the same workshop, the International Service for the Acquisition of Agri-biotech Applications (ISAAA, an industry-supported biotech advocacy group) facilitated discussions on "effective" biotech communication and "sound" media relations. In January 2010, WEMA hosted a workshop for East African journalists to build capacity for reporting on biotechnology.

**Water Efficient Maize for Africa** (WEMA) is one of AATF's five projects. This public/private partnership involves Monsanto, BASF, the CGIAR's flagship research centre – the International Maize and Wheat Improvement Center (CIMMYT), and national agricultural research systems in Kenya, Mozambique, South Africa, Tanzania and Uganda. Launched in 2008 with $47 million from the Bill and Melinda Gates Foundation and the Howard G. Buffett Foundation, WEMA's goal is to develop new drought-tolerant maize varieties that are adapted to African agro-ecologies using conventional breeding as well as transgenics. In addition to proprietary germplasm, advanced breeding tools, and expertise, Monsanto and BASF announced in March 2008 the donation of royalty-free drought-tolerant transgenes, "the same water-use efficiency genes being developed for commercial global markets." Monsanto describes its donation as a "gem" in its technology pipeline and predicts it could result in new white maize varieties that increase yields 20-35% during moderate drought. In June 2008, Monsanto's CEO Hugh Grant ramped up the rhetoric, pledging that his company would not only double crop yields in corn, soybeans and cotton by 2020, but also help improve farmers' lives, "including an additional five million people in resource-poor farm families by 2020."

**What has WEMA accomplished since 2008?** According to AATF, during the project's first two years more than 60 scientists worked together to build "the necessary scientific testing, regulatory procedures and protocols for the proper evaluation of the maize in this project within each of the five countries." Non-transgenic water-efficient maize varieties (conventionally-bred) are now in the second year of field trials in Kenya and Uganda, and Tanzania recently planted trials for the first time.

As of September 2010, South Africa is the only one of five WEMA countries to conduct field trials of transgenic, drought-tolerant maize. WEMA's first transgenic maize varieties were planted in November 2009 at Lutzville, a testing site in the Western Cape of South Africa, to screen for drought-tolerance performance under both optimum and low soil nitrogen. According to AATF, "In the next 12 months pending necessary regulatory approvals, it is expected scientists will be able to proceed with the planting of biotech trials in Kenya, Tanzania and Uganda. Mozambique will take steps towards completing the development of testing sites and secure regulatory approvals with a goal of planting in 2011."

According to Grace Wachoro, Communications Officer at AATF, WEMA scientists have introduced Monsanto's drought-tolerant gene in adapted African maize lines that will undergo "preliminary testing" in Kenya and Uganda. She adds that "The integration of the drought gene(s) is a continuous process so that there will be a pipeline of hybrids to test in the WEMA countries throughout the project." Wachoro notes that all WEMA partners are parties to the Cartagena Protocol on Biosafety and "have all committed to building functional national biosafety frameworks for managing GMOs." As of this writing, Uganda has drafted a national biosafety bill, which is pending approval by Parliament. .

Another AATF project related to climate-ready crops seeks to develop rice varieties suitable for soils that are low in nitrogen and for drought and salt tolerance. The project claims that rice varieties with these traits will help African farmers increase yields by up to 30%. Partners include **USAID**, **Arcadia Biosciences** (USA), National Agricultural Research Systems in **Ghana**, **Burkina Faso**, **Nigeria**, the **International Center for Tropical Agriculture** (Colombia), and **PIPRA** (USA). Arcadia will provide a technology license to make the new rice varieties royalty-free to smallholder African farmers.

**"Improved Maize for African Soils."** In February 2010, **Pioneer (DuPont)** announced the "Improved Maize for African Soils" (IMAS) collaboration, a public-private partnership that aims to increase maize yields in Africa by 30-50% over currently available varieties – without increasing the use of fertilizer. The project is led by **CIMMYT**, with $19.5 million in grants from the **Bill & Melinda Gates Foundation** and **USAID**. Other partners include the Kenya Agricultural Research Institute (KARI) and the South African Agricultural Research Council. Maize varieties developed with the technologies and intellectual property donated by Pioneer (transgenes and molecular markers associated with nitrogen-use efficiency) "will be made available royalty-free to seed companies that sell to the region's smallholder farmers, meaning that the seed will become available to farmers at the same cost as other types of improved maize seed."[89]

Pioneer claims that it holds "a rich pipeline" of genes for nitrogen efficiency. "By applying these genes and our Accelerated Yield Technology™ resources to the IMAS effort, we will help ensure the development of improved maize lines for those who have the most to gain from using new technologies – the smallholder farmers." Technologies will be introduced in phases: Over the next four years the project will introduce conventional maize varieties (non-GM) that offer a "significant yield advantage." Varieties developed using DNA marker techniques will be introduced within approximately seven to nine years, and those with transgenic traits will be available in approximately 10 years. All of this depends, of course, on "pending product performance and regulatory approvals by national regulatory and scientific authorities" according to national laws in each country.

In April 2009, the **Syngenta Foundation for Sustainable Agriculture** and the Forum for Agricultural Research in Africa (FARA) signed a 3-year, $1.2 million agreement "to strengthen the capacity for safe biotechnology management" in Sub-Saharan Africa. The project is managed by FARA and implemented by the National Agricultural Research System in Burkina Faso, Ghana, Nigeria, Kenya, Uganda and Malawi. According to Lucy Muchoki, a Board Member of FARA, "the project stewardship capacity that will be developed will underpin future initiatives for the proper deployment of proprietary biotechnology in the selected countries. The beneficiary countries will serve as mentors for sister countries in their respective sub-regions for the safe deployment of modern biotechnology." As *Ghana Web* reports, FARA is urging Ghanaians "to embrace the use and application of modern biotechnology to effectively solve food insecurity and the likely impact of climate change on farming."

In 2008 **Arcadia Biosciences** (Davis, California, USA) won a 3-year, $3.6 million grant from USAID to develop rice and wheat varieties that are tolerant to drought and salinity and use nitrogen more efficiently. Arcadia will partner with Mahyco, the Indian seed company partly owned by **Monsanto**, to develop and commercialize the GM varieties.[90] The initial grant is expected to leverage an additional $18.5 million of investment. The companies will work with the Indian public sector in order "to broaden the reach" of the technology. USAID will also assist Arcadia and Mahyco to establish markets in Bangladesh or Pakistan.

## International Agricultural Research Responds to Climate Change

The goal of "climate-proofing" poor peoples' crops is also reinvigorating international plant breeding institutes that see their mission as providing science-based solutions to hunger, poverty and food insecurity in the global South. In 2006, the network of 15 "Future Harvest" centres that operate under the umbrella of the Consultative Group on International Agricultural Research (CGIAR) announced plans to intensify research on "climate ready" crops in order to blunt the impact of global warming.[91] (In fact, the CGIAR was first to use the term "climate ready" to refer to plant breeding efforts to develop abiotic stress tolerance in crops. Whether intentional or not, it immediately brings to mind Monsanto's herbicide-tolerant, "Roundup Ready" transgenic crops).

In 2006, the CGIAR spent about $70 million on climate change-related research (15% of its total budget of $470 million). This work included studies to assess vulnerability of agricultural systems in the developing world to climate change. At the end of 2007, CGIAR pledged to at least double the amount it devotes to climate-change research, including research for: (i) Plant breeding for resistance to diseases and insects as well as abiotic stresses such as drought and flooding; (ii) Cropping systems (soil management, crop diversification, integration of crops and livestock); (iii) Water management (technologies and policies to increase water-use efficiency).

CGIAR scientists are using classical breeding, marker-assisted selection, and genetic engineering to improve "defensive traits" in widely-cultivated, high yielding varieties. The highest-profile research focuses on climate-resilient cereals – especially maize and rice – for the tropics. Most of CGIAR's research does not currently employ transgenics, but that could change soon. CGIAR also points out that its focus on abiotic stress tolerance in crops is not new. Working with national agricultural researchers in sub-Saharan Africa, CIMMYT claims that it has so far developed more than 50 drought-tolerant maize varieties (conventionally bred) that are being grown on about one million hectares worldwide.

**CGIAR's Transgenic Research on Drought and Stress Tolerance.** Although corporate spending on climate-tolerant transgenic research far exceeds the amount spent by publicly-funded institutes, several CGIAR centres are conducting research on transgenic stress tolerance in crops, especially transcription factors (e.g., dehydration responsive element binding [DREB] proteins) in wheat, rice, groundnut (peanut) and potatoes.

At its headquarters in Mexico, CIMMYT researchers inserted the DREB1A gene from *Arabidopsis thaliana* into wheat. In 2004, despite international controversy over transgenic wheat trials (GM wheat has not yet been commercialized), CIMMYT conducted transgenic wheat field trials in Mexico, and plans to conduct more trials in the future.[92] The gene construct, provided by the Japan International Research Center for Agricultural Sciences, reportedly confers crop tolerance to drought, low temperatures and salinity. In CIMMYT's 2004 Annual Report, its lead researcher on drought-tolerant wheat, Allesandro Pellegrineschi, stated that, given the appropriate investment, it might be possible to produce drought-tolerant transgenic varieties within five years. Pellegrineschi is now at DuPont (Pioneer).

Researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India are also using the DREB1A gene to develop drought-tolerant transgenic groundnuts (peanuts) and pigeonpeas. According to ICRISAT researchers, the transgenic crops have not yet been field-tested.

**Added Biosafety Concerns.** CIMMYT acknowledges that the development of crops engineered for environmental stress tolerance will "require substantial advances in biosafety assessment and regulatory approval that are very different to the first generation of commercial transgenic crops."[93]

CIMMYT cautions: "Genetically engineered crops for abiotic stress-prone environments pose new questions regarding safety and impact. For example, new phenotypes resulting from transgenic technology for abiotic stressful environments may lead to increased competitiveness if the transgenes are introgressed into wild populations. Furthermore, the use of regulatory genes such as *DREB* may potentially have a cascading effect on a variety of gene pathways (as compared to the first generation of transgenic crops which were based on one gene-one product systems). Some of these cascade effects will be intended while other will not, some will be known but others will be less easy to define."[94]

**CIMMYT's New Partnership Paradigm.** Despite biosafety concerns, CIMMYT is prepared to embrace transgenic drought-tolerant crops for sub-Saharan Africa. CIMMYT researchers acknowledge that multinational companies control key genes for drought tolerance in transgenic crops, and that public sector deployment of patented transgenes could raise liability issues if researchers were accused of infringing patented genes or technology. As a way to avoid liability issues, CIMMYT researchers propose that a "user-led philanthropy-private-public partnership paradigm" could make possible "transgenic solutions" for drought-tolerant maize in sub-Saharan Africa.[95] CIMMYT researchers write:

"If this new partnership paradigm succeeds, the access to proprietary technologies that can lead to stable grain yields in complex drought-prone areas will allow resource-poor African maize farmers to harvest a reasonable crop in most years, which will almost certainly lead to improved food security, better well-being, enhanced livelihoods and increased opportunities to enter the market economy, even for farmers residing in harsh environments."[96]

To bring the new "partnership paradigm" to fruition, CIMMYT researchers proposed to facilitate dialogue with the relevant corporation "to ensure this transgenic technology becomes available to the resource-poor maize farmers of sub-Saharan Africa." ETC Group does not know if the facilitated dialogue ever took place with the relevant corporation. We do know that CIMMYT and national agricultural research programs of Kenya, Uganda, Tanzania and South Africa are working jointly to develop drought-tolerant maize (2008's $47 million grant from the Bill & Melinda Gates Foundation).

In other words, CGIAR is side-stepping controversial issues of ownership and control of drought-tolerant genes, and at the same time facilitating and supporting the introduction of genetically engineered crops in sub-Saharan Africa. The Bill & Melinda Gates Foundation – which is becoming a major funder of the CGIAR system – is clearly influencing CGIAR support for a market-based orientation to the introduction of agricultural technology in Africa. Gates's market-based approach will ultimately mean a dumping of high-tech seeds accompanied by intellectual property laws, seed regulations and other practices amenable to agribusiness. To African farmers, this is hardly philanthropic.

In return for the surrender of national sovereignty over intellectual property, biomass, and national food security, the Gene Giants are offering to "donate" proprietary genes (for untested and unproven technologies) to resource poor farmers. No government need ever recognize patents on these genes. This "magnamity" calls for an immediate investigation of all national and international patent arrangements where such claims have been entertained.

CIMMYT's unilateral action raises a policy turf issue with FAO. CGIAR's 15 institutes agreed more than a decade ago that policy oversight regarding the use of plant genetic resources would rest with the FAO Commission on Genetic Resources for Food and Agriculture, and that any changes in CGIAR policies would have to be cleared by the FAO Commission. Since the BASF/Monsanto proprietary traits may be inserted into CIMMYT's publicly-held germplasm and subjected to unknown licensing conditions, clearance from the FAO Commission is necessary.

The trilateral partnership is controversial because the Gates and Rockefeller Foundations' Alliance for a Green Revolution for Africa (AGRA) has pledged *not* to introduce GM seeds during its first 5-year program. By working with national agricultural researchers and CIMMYT on a separately funded program for drought-tolerant maize (outside of the AGRA envelope), all three parties seemingly duck accountability for research supporting the introduction of genetically engineered seeds in sub-Saharan Africa. The big winners, of course, are BASF and Monsanto. They can now point to their philanthropic efforts to give royalty-free drought-tolerant genes to the neediest farmers in Africa – with full endorsement from public plant breeding institutes.

***"What we need in order to effectively contribute…are enabling business environments."***

Gerald Steiner, Executive Vice President, Sustainability and Corporate Affairs, Monsanto Company, testifying before the US Congress, July 2010.[97]

**"IP for the Poor"** is also a rallying cry at the intergovernmental level. In January 2011, the World Intellectual Property Organization (WIPO) plans to unveil a "Global Responsibility Licensing Initiative" that would allow corporations to issue free licenses in food security, health and environment technologies.[98] According to WIPO's Director General, Francis Gurry, "Essentially, voluntarily a corporation would agree to make available free of charge its technologies where they have no market, usually a humanitarian situation or where there are no consumers."[99]

The WIPO initiative was developed with input from the World Economic Forum and the Bill & Melinda Gates Foundation (among others). Perhaps this is WIPO's idea of how to implement its so-called "Development Agenda." By casting the patent giveaway as a magnanimous act, the WIPO initiative will generate positive PR for giant corporations and implicit legitimacy for monopoly patents – even in South countries that are not obligated to recognize them. A patent is a government-granted monopoly and is valid only within its territorial boundaries (although there are some multi-national regional patent offices).[100] In reality, patents are not insurmountable obstacles for poor countries. A patented technology may be used wherever and whenever the patent monopoly is not in force – it isn't necessary to obtain a license from the patent holder.[101]

## REALITY CHECK: WILL IT WORK?

The technical complexity of developing transgenic plants engineered to withstand environmental stresses associated with climate change has been noted in recent studies and by some developers themselves. A 2010 study points out: "The acclimation of plants to abiotic stress conditions is a complex and coordinated response involving hundreds of genes."[102] The authors note that a plant's response to abiotic stress is affected by complex interactions between different environmental factors. The timing of the abiotic stress, its intensity and duration, and the occurrence of multiple stresses in the field must all be taken into consideration.

### Corporate Rhetoric vs. Technical Complexity

Genetically engineered drought-tolerant plants are so far proving problematic. You're not likely to read a straightforward analysis of the problems in published scientific papers authored by company scientists, but other researchers focusing on drought are identifying problems.[103] The key stumbling block is known as the "pleiotropic effect."

Researchers pursuing genetically engineered drought-tolerance are finding that expressing genes for drought-tolerance can have unpredictable and unwanted effects on other traits, including yield and quality. Like a sluggish computer that's over-loaded with bloated software, the genes associated with drought tolerance slow down the plant's development, resulting in smaller plants and delayed flowering. According to a report prepared by Australia's Grains Research and Development Corporation, **"The flaw is a profound one. It amounts to shifting the yield losses experienced in dry seasons onto the good years."**[104]

Researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India also report drawbacks working with stress-responsive genes in transgenic crops. In a 2007 article, they write: "Evaluation of the transgenic plants under stress conditions, and understanding the physiological effect of the inserted genes at the whole plant level, remain as major challenges to overcome."[105]

**Terminology**
**Pleiotropy** – The ability of a single genetic change to cause unintended physiological effects throughout a plant. Companies focusing on genetically engineered drought-tolerance are finding that genes for drought-tolerance can have unwanted effects on other traits, including yield and quality.

The extreme complexity of engineering abiotic traits in plants is a technical feat that far surpasses what genetic engineers have achieved over the past quarter century. Fourteen years after commercial sale of the first genetically engineered crops, the Gene Giants have brought to market only two major *single-gene* traits – herbicide tolerance and insect resistance – in a handful of countries.

Setting aside the potential for adverse social and environmental impacts of these products, the advantages of GE crops – *even for industrial-scale farmers in the North* – are elusive. Of course, even the biotech industry has admitted their products offer no benefits for consumers. In October 2010 the *New York Times* acknowledged that industry analysts were questioning whether "Monsanto's winning streak of creating ever more expensive genetically engineered crops is coming to an end."[106] The company's newest product, "SmartStax" maize (loaded with eight foreign genes for insect resistance and herbicide tolerance), has been deemed a commercial flop. But that's not all. A huge percentage of the global area devoted to biotech crops contains at least one engineered gene for tolerance to Monsanto's Roundup – the company's blockbuster herbicide. But Roundup-resistant weeds are popping up all over the world, a reality "dimming the future of the entire Roundup Ready crop franchise."[107] By 2015, an estimated 40% of all US farmland planted in maize and soybeans will contain some Roundup-resistant weeds.[108] It may be bad news for farmers, but it's a bonanza for agrochemical giants. Because of the growing problem of Roundup-resistant weeds, pesticide firms are scrambling to engineer crops that will resist even more toxic herbicides (like 2,4-D). A spokesman for Syngenta told the *Wall Street Journal*: "The herbicide business used to be good before Roundup nearly wiped it out. Now it is getting fun again."[109]

**The Opportunity Cost.** The question is not simply whether it is technically possible to engineer climate-ready crops. A bigger question looms, especially for the public/private initiatives that are investing millions to deliver proprietary, climate-ready products to the poor. ***What is the best use of limited resources?*** Proprietary research on genetically engineered abiotic stress tolerance is already diverting scarce resources away from more affordable and decentralized approaches to cope with climate change. What might 60 scientists in Africa achieve if they weren't focusing on transgenic maize?

**Non-Transgenic Research.** Although CGIAR appears to embrace the promise of transgenics for Africa, the vast majority of the Group's breeding work for abiotic stress tolerance does not (yet) involve genetically engineered crops. Most of the current research involves identifying traits in farmers' seeds and using classical breeding and marker-assisted selection to develop new varieties. Two prominent examples appear in box below.

## Farmers' Crop Diversity as Source of Adaptive Traits

**Waterproofing rice:** Flooding and seasonal flashfloods already cause losses worth $1 billion per annum to rice farms in South and Southeast Asia, conditions that are expected to worsen with rising sea levels and extreme climate events. When scientists from the International Rice Research Institute (IRRI) and the University of California-Davis started searching for genes that would allow Asian rice to withstand prolonged flooding, they knew right where to look: a farmers' variety, Dhullaputia,[110] identified over 50 years ago in Orissa, India as the world's most flood-tolerant rice variety.[111] Using marker-assisted selection (not transgenics), the researchers were able to isolate the submergence tolerant gene, Sub1A, and then transfer it to a rice variety that is grown on more than 5 million hectares in India and Bangladesh, known as *Swarna*. Most rice can tolerate flooding for only a few days, but researchers say the new variety, *Swarna-Sub1*, can withstand submergence for two weeks without affecting yields. IRRI released seeds of the flood resistant rice variety in the Philippines and Indonesia in 2009 and 2010, respectively.[112]

**Beating the heat:** Rice is now the fastest growing food source in sub-Saharan Africa, and CGIAR scientists predict it will become the leading agricultural commodity in many parts of the continent.[113] The African Rice Center (WARDA) is developing heat- and drought-tolerant rice varieties by crossing African rice species (*O. glaberrima)* with the higher yielding Asian rice (*O. sativa)*.[114] Not surprisingly, drought-prone environments of Africa are precisely where researchers have found traditional African rice that can withstand hot and dry conditions. Drought-tolerant features of African rice (*O. glaberrima)* include, for example, deep and thick roots, early maturity, rapid leaf rolling and high water-use efficiency.

Researchers have identified traits in African rice that make it more tolerant to heat stress. *O. glaberrima* has a mechanism that limits transpiration rates – meaning evaporation of water from the plant's leaves – allowing it to avoid heat stress during hotter and dryer conditions.[115] African rice also offers the advantage of flowering earlier in the morning when the temperature is lower. This is especially important because rice is extremely sensitive to high temperatures during flowering (over a 2-3 week period). When temperatures exceed about 35° C, the viability of pollen is greatly reduced, causing yield loss. The peak time of day for flowering of most Asian rice (*O. sativa*) varieties is 11 am, when temperatures in many rice growing regions of Africa can surpass 35° C. By contrast, *O. glaberrima* usually flowers early in the morning, at around 7 or 8 am, allowing it to escape the hottest temperatures of the day. Shifting flowering to the early morning hours is one strategy breeders are pursuing to protect rice from adverse effects of climate change.

# FARMER RESILIENCE AND ADAPTATION

The world cannot rely on technological fixes to solve problems of poverty, hunger, and climate crisis. A highly centralized agro-industrial food system controlled by a handful of corporate "Biomassters" is incapable of providing the systemic changes needed to re-structure agricultural production and reduce greenhouse gas emissions. Meanwhile, peasant farmers, civil society and social movements are actively building alternative food systems built on resilience, sustainability and sovereignty.

Climate resilience ultimately depends on agricultural biodiversity, local seed systems and agro-ecological processes in the hands of farming communities. Support is needed for breeding work with under-utilized crops and with plant diversity that offers natural tolerance to harsh conditions. Indigenous and local farming communities have developed and managed that diversity and their role in developing strategies for climate change adaptation must be recognized, strengthened and protected. Instead of being on the receiving end of corporate-inspired, high-tech "hand-outs," farming communities must be directly involved in setting priorities and strategies for climate adaptation and mitigation.

## Farmer-Based Strategies for Resilience in Confronting Climate Change

> "Adaptation is ultimately about building the resilience of the world's poor to a problem largely created by the world's richest nations."[116]
>
> UNDP, *Human Development Report 2007/2008*

Formal sector scientists are not the only innovators. Even using the most sophisticated climate models and the most advanced technologies, the reality is that scientists are not very good at predicting what happens at a very local level – on and in the ground.

The genetic diversity of plants and animals and the diverse knowledge and practices of farming communities are the two most important resources for adapting agriculture to local environmental conditions. Genetic diversity has enabled agriculture to respond to change over the past 10,000 years and it's precisely this diversity that will play a key role in adapting agriculture to climate chaos in the decades ahead.

In local seed systems, the primary emphasis is not on high yields and productivity, but on resilience and risk-adverse qualities in the face of harsh, variable and sometimes unpredictable conditions. An essential component in adaptive strategies is plant breeding, especially at the local level. Crop genetic diversity plays a key role in coping with environmental stresses and is the cornerstone of small farmers' livelihood strategies, especially in the South. A 2008 study by FAO on local seed systems in four Southern African countries found that over 95 percent of the seed used by farmers is locally produced.[117] Worldwide, an estimated 1 billion people depend on farmer-saved seeds. FAO's study notes that small farmers can benefit from the introduction of improved genetic materials, but that "the limitation of the formal sector lies in its incapacity to address widely varying agro-ecological conditions or the needs and preferences of small-scale farmers."[118]

> "A powerful tool for meeting development and sustainability goals resides in empowering farmers to innovatively manage soils, water, biological resources, pests, disease vectors, genetic diversity, and conserve natural resources in a culturally appropriate manner."
>
> Executive Summary of the Synthesis Report of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), April 2008[119]

While genetic uniformity is the hallmark of commercial plant breeding (uniformity being a criterion for plant intellectual property), farmer-breeders deliberately create and maintain more heterogeneous varieties in order to withstand diverse and adverse agro-ecological conditions. These plant breeding skills, rooted in local-level realities, are needed to adapt agriculture to climate change.

Seed diversity is managed and used in a dynamic and complex system. It includes traditional staple crops, market crops, minor crops, and wild plant species. Farming communities manage/maintain thousands of crops/species and wild plants that are not part of international trade and have been largely neglected or overlooked by formal sector breeders. Gene banks hold only a small fraction of the germplasm that will be needed for future breeding work. For example, only about one-third of the species currently conserved in gene banks are classified as "landraces" (i.e., farmer's varieties) or "primitive cultivars." Minor, underutilized crop species and wild relatives are severely under-represented. By one estimate, well over 90% of useful genetic variability may still be in the wild.[120] (For example, it is estimated that only 35% of the genetic diversity of cassava, one of the world's most important root crops, has been collected.) Similarly, many wild relatives of crops, which FAO identifies as particularly important for the food and livelihood security of farming communities, are not represented in gene bank collections.[121] Wild crop relatives and minor crops are now recognized as a valuable and relatively untapped source of adaptive breeding traits. Whether in intensive, market-oriented or marginal production systems, recent studies are confirming what farming communities already know: farmers are plant breeders who actively develop new crop varieties.[122]

The crop diversity developed and maintained by farming communities already plays a role in adapting agriculture to climate change and variability. And history shows that farmer-bred seeds can be adopted and dispersed rather quickly. In Nepal, for instance, two farming communities in the same valley developed new rice varieties for high-altitude areas. One of the farmers' varieties performed much better than rice varieties introduced by the formal sector and was subsequently adopted by farmers and spread over wide areas.[123] In the Brazilian community of Sol da Manha, farmers and formal sector breeders collaborated in the improvement of a local maize variety selected for low nitrogen use.[124]

Farmers typically draw on breeding materials from within their own communities as well as germplasm introduced from outside, including commercial varieties. SEARICE, a Philippines-based civil society organization, reports that during the 10-year period 1994-2004, the Philippines' rice research institute released 55 inbred rice varieties. During the same decade (over an 8-year period, 1998-2004), farmer-breeders on the island of Bohol developed 89 rice varieties.[125]

Climate models predict that major food crops of particular importance for food security in the South are especially vulnerable to impacts of climate change (for example, Southeast Asia rice and Southern Africa maize). One important adaptation strategy for farmers is to switch from highly vulnerable to less vulnerable crops.[126] Crop diversification must also include under-utilized species that offer natural tolerance to environmental stresses such as heat, drought, cold, etc.

Adaptation to climate change is not just about seeds – it's about farming systems. Farmers can adapt to changing climate by shifting planting dates, choosing varieties with different growth duration, changing crop rotations, diversifying crops, using new irrigation systems, and so on. Farmers cultivate early- and late-maturing varieties of the same crops to increase the period of food availability and to spread out the amount of labour required at harvest time.

Farmer-led strategies for climate change survival and adaptation must be recognized, strengthened and protected. Farming communities must be directly involved in setting priorities and strategies for adaptation. Where appropriate, formal sector scientists can work with farmers to improve conservation technologies, strengthen local breeding strategies, and assist in identifying and accessing seed accessions held in seed banks. This may involve strengthening and expanding farmer-to-farmer networks for exchanging and enhancing crops and varieties that are already well-adapted to local environments. It may also involve facilitating access to new sources of germplasm for farmer experimentation and breeding.

## Alternative Solutions for Climate Resilience

***Home gardens:*** Small farmers manage a major portion of the world's agro-biodiversity in complex agro-ecosystems that have been largely neglected or overlooked by formal sector breeders. A recent study points to home gardens as crucial reservoirs of rich agricultural biodiversity at multiple levels (for example, wild, semi-domesticated and domesticated plants, as well as inter- and intra-specific diversity).[127] These "neglected hotspots of agro-biodiversity and cultural diversity" are a critical resource for traditional knowledge, conservation of agricultural biodiversity and climate change adaptation.[128] Gardens surveyed in Ghana, for example, reveal that home gardeners cultivate, on average, 45 species; Nepalese gardeners maintain an average 33 species; Vietnamese home gardeners cultivate 45 species.[129] Home gardens typically include plants grown for food, fodder, medicine, fuel, fibre and ornamentals.

***Wild food species:*** Although natural habitats are severely threatened, indigenous peoples and farming and foraging communities actively manage wild plants and animals that provide a major – though undervalued – contribution to the world's food supply. A recent study by Zareen Bharucha and Jules Pretty reveals that the mean use is 120 wild species per community for indigenous communities in both industrialized and developing countries.[130] In 22 countries of Asia and Africa, the mean use is 90-100 wild species per location. In countries like India, Ethiopia and Kenya, aggregate country estimates reached 300-800 species. [131] Bharucha and Pretty note that wild food species "offer a potentially critical role for buffering against food stress caused by a changing climate" and, due to the innate resilience of some wild species, "could play an increasingly important role during periods of low agricultural productivity associated with climate events."[132]

***Traditional varieties:*** The New Delhi-based Navdanya/Research Foundation for Science, Technology and Ecology points out that traditional crops bred by farmers are the major source of traits for climate resistance.[133] In its 2009 report, *Biopiracy of Climate Resilient Crops*, Navdanya documents drought-resistant rice varieties grown by traditional farmers in Uttarakhand, West Bengal, Kerala, and Karnataka, and flood resistant rice varieties grown in Assam, West Bengal, Orissa, Kerala and Karnataka. Saline-resistant rice varieties are grown in the mangroves of Sunderban area of West Bengal, Orissa, Kerala, and northern Karnataka.

***Under-utilized crops:*** Researchers from the US National Research Council asked African experts to nominate indigenous African food plants with unrealized potential that are typically overlooked by scientists, policymakers, and the world at large. They received 1,000 responses naming over 300 key plants, including more than 50 vegetables.[134] In its study on under-valued crops of the Andes, the National Research Council notes that, "traditional Andean crops have received little scientific respect, research, or commercial advancement. Yet they include some widely adaptable, extremely nutritious, and remarkably tasty foods."[135] The hidden harvests, undervalued biodiversity, and the knowledge and resources of the world's indigenous and peasant farming communities must be harnessed to achieve climate security.

**No Climate Safety Net.** The detrimental effects of climate crisis are not just a matter of geographic vulnerability, but are also determined by a region's ability to pay for adaptation measures. For some farmers in OECD countries, for example, risks are already mitigated through agricultural subsidies – around $225 billion in OECD countries in 2005[136] – and through public support for disaster insurance. For poor countries, there is no climate safety net. Even the most basic resources are scarce. Currently, Africa has one meteorological station for every 25,460 km$^2$ – one-eighth the minimum level recommended by the World Meteorological Organization. By contrast, the Netherlands has one weather station for every 716 km$^2$.[137] Investment in plant breeding is another important adaptation measure. A survey of 19 African countries by FAO reveals that financial support for plant breeding in 2005 was lower than it had been in 1985.[138]

## Climate Change: Corporate Response vs. Farmer Response

***In Silico* vs. *In Situ***

| **Gene Giant Approach** | **Farmer Approach** |
|---|---|
| Uses *in silico* approach (massive computer data and robotics) to find interesting genes and traits. | Selects the most resilient plant varieties. |
| Uses functional genomics to identify and over-express genes for abiotic stress tolerance. | Investigates under-utilized species that offer natural tolerance to environmental stresses such as heat, drought, cold, etc. |
| Files for exclusive monopoly patents on abiotic stress related traits for multi-genomes. | Eliminates all barriers to germplasm exchange, including intellectual property, WTO-inspired seed laws, phony trade barriers, corporate oligopoly, etc. |
| Wins market-based subsidies for use of climate ready crops or…convinces government regulators that farmers must plant proprietary climate-ready seeds. | Engages in farmer-to-farmer alliances and germplasm exchanges as well as appropriate partnerships with formal sector breeders |

## Conclusion

The Gene Giants are leveraging the climate crisis to win monopoly control of key crop genes and gain public acceptance of genetically engineered seeds. Instead of focusing on policies to dramatically cut consumption of fossil fuels and assist farmers with community-controlled breeding strategies, the corporate agenda focuses on proprietary, high-tech seeds that will be neither accessible nor suitable for the vast majority of the world's farmers. Genetically engineered, climate-ready crops are a false solution to climate change and the patent grab must be stopped.

There is no societal benefit when governments allow a handful of corporations to monopolize climate-related genes and traits. Two years after our initial study on climate-ready patent claims, ETC Group's recommendations remain:

- Suspend all patents on climate-related genes and traits and conduct a full investigation, including of the potential environmental and social impacts of transgenic abiotic stress tolerant seeds.
- Recognize, protect and strengthen farmer-based breeding, conservation and agro-ecological systems as a priority response for climate change survival and adaptation.
- Adopt policies to facilitate farmers' access to and exchange of breeding materials and eliminate current restrictions on access to seeds and germplasm (especially those driven by intellectual property, agribusiness-inspired seed laws, trade regimes and corporate oligopoly). In the midst of a food crisis compounded by climate crisis, restrictions on access to seeds and germplasm are the last thing farmers need in their struggle to adapt to rapidly changing climatic conditions.

## About ETC Group

ETC Group is an international civil society organization. We address the global socioeconomic and ecological issues surrounding new technologies with special concern for their impact on indigenous peoples, rural communities and biodiversity. We investigate ecological erosion (including the erosion of cultures and human rights), the development of new technologies, and we monitor global governance issues including corporate concentration and trade in technologies. We operate at the global political level and have consultative status with several UN agencies and treaties. We work closely with other civil society organizations (CSOs) and social movements, especially in Africa, Asia and Latin America. We have offices in Canada, USA, Mexico and Philippines. www.etcgroup.org

This pre-publication version of this report is an amalgam and update of two previous ETC Group Reports :

**Patenting the "Climate Genes"…And Capturing the Climate Agenda, May/June 2008**

**Gene Giants Stockpile Patents on "Climate-Ready" Crops in Bid to Become Biomassters, October 2010**

Research / Writing by **Hope Shand**. Artwork / Cover Design by **Stig**. Cover Art : Approaching Storm by **Grant Wood** (1940)

[1] Jack Kaskey and Antonio Ligi, "Monsanto, Dupont Race to Win $2.7 Billion Drought-Corn Market," *Business Week*, 21 April 2010. Available online at: www.businessweek.com/news/2010-04-21/monsanto-dupont-race-to-win-2-7-billion-drought-corn-market.html

[2] US Department of Agriculture, 2008. "US Biobased Products: Market Potential and Projections Through 2025." Office of the Chief Economist, Office of Energy Policy and New Uses, US Department of Agriculture. Prepared jointly by the Office of Energy Policy and New Uses, the Center for Industrial Research and Service of Iowa State University, Informa Economics, Michigan Biotechnology Institute, and The Windmill Group. OCE-2008-1, 293 pp.

3 United Nations Development Programme (UNDP), "Human Development Report 2007/2008: Fighting Climate Change: Human Solidarity in a Divided World," 2007, p. v.

4 FAO, Press Release, "Agriculture in the Near East likely to suffer from climate change," Rome/Cairo, 3 March 2008. Available online at: www.fao.org/newsroom/en/news/2008/1000800/index.html

5 United Nations News Centre, FAO, "Climate change threatens crop losses, more hungry people – UN," 26 May 2005.

6 Philip K. Thornton, et al., "Mapping Climate Vulnerability and Poverty in Africa, International Livestock Research Institute," May 2006. The report finds that many communities across Africa that are already grappling with severe poverty are also at the crosshairs of the most adverse effects of climate change. Most vulnerable of all are farming families in East and Central Africa, including Rwanda, Burundi, Eritrea, and Ethiopia as well as Chad and Niger. Available online at : http://dspace.ilri.org:8080/jspui/bitstream/10568/2307/1/Mapping_Vuln_Africa.pdf

7 UNDP, "Human Development Report 2007/2008," p. 92.

8 IRRI, Press Release, "Rice harvests more affected than first thought by global warming," 29 June 2004. The study was published in *Proceedings of the National Academy of Sciences*.

9 Consultative Group on International Agricultural Research, News Release, "Intensified Research Effort Yields Climate-Resilient Agriculture To Blunt Impact of Global Warming, Prevent Widespread Hunger," 4 December 2006. Available online at: www.cgiar.org/pdf/agm06/AGM06%20Press%20Release%20FINAL.pdf The title of the forthcoming study is, "Can Wheat Beat the Heat?"

10 CGIAR, "Global Climate Change: Can Agriculture Cope?" Online Briefing Dossier, 2007. Available online at: www.cgiar.org/impact/global/cc_mappingthemenace.html

11 UNDP, "Human Development Report 2007/2008," p. 94.

12 CGIAR, "Global Climate Change: Can Agriculture Cope?" Online Briefing Dossier, 2007. Available online at: www.cgiar.org/impact/global/cc_mappingthemenace.html

13 Based on information from David B. Lobell. Summary statement from a Bellagio meeting, held on September 3-7, 2007, "The Conservation of Global Crop Genetic Resources In the Face of Climate Change." David B. Lobell et al., "Prioritizing Climate Change Adaptation Needs for Food Security in 2030," *Science*, 2008, **319**: 607-610.

14 Kaskey, op. cit., "Monsanto, Dupont Race to Win $2.7 Billion Drought-Corn Market."

15 Legal ownership of the patent or patent application is designated as the "assignee." However, patent rights may be traded and the patent – some or all rights – may be licensed to another party. This information is not disclosed on patent documents.

16 Charlotte Eyre, "Australia gives go-ahead for GM wheat testing," Food Navigator.com, 20 June 2006. Available online at: the Internet: http://www.foodnavigator.com/Financial-Industry/Australia-gives-go-ahead-for-GM-wheat-testing

17 Carey Gillam, "Biotech companies race for drought-tolerant crops," *Scientific American*, 13 January 2008. www.sciam.com

18 Gio Braidotti, "Scientists share keys to drought tolerance," Australian Government Grains Research Development Corporation, *Ground Cover* Issue 72, Jan.-Feb. 2008.

19 African Agricultural Technology Foundation, "African Agricultural Technology Foundation to develop drought-tolerant maize varieties for small-scale farmers in Africa," News release, March 19, 2008.

20 James Z. Zhang, et al. "From Laboratory to Field: Using Information from *Arabidopsis* to Engineer Salt, Cold, and Drought Tolerance in Crops," *Plant Physiology*, June 2004, Vol. 135, pp. 615-621.

21 Ibid.

22 Mendel Biotechnology, Inc., US patent application no. US20070240243A9: Plant transcriptional regulators of drought stress in "background of the invention."

23 See, for example, US Patent No. 7,241,937.

24 See, for example, US Patent No. 7,230,165.

25 Arren Bar-Even, et al., "Design and analysis of synthetic carbon fixation pathways," *PNAS, Proceedings of the National Academy of Sciences*. Available online at : www.pnas.org/content/107/19/8889

26 Ibid.

27 Personal communication with Ron Milo, Weizmann Institute.

28 Dupont, "DuPont Leader: Drought-tolerant Crops Critical to Increasing Food Production," News release, Aug. 4, 2010. Available online at: www.pioneer.com/web/site/portal/menuitem.50ccfe7db37d91e389108910d10093a0/

29 Personal communication with Jeffrey Rowe, Pioneer Hi-Bred International (DuPont).

*30* Ibid.

31 Carey Gillam, "Biotech companies race for drought-tolerant crops," Reuters, January 13, 2008.

32 AgBioWorld, September 4, 2006. Available online at: http://www.agbioworld.org/newsletter_wm/index.php?caseid=archivenewsid=2590

33 Pioneer "DuPont and Evogene Collaborate to Increase Drought Tolerance in Corn and Soybeans," News release, October 30, 2007. www.pioneer.com

34 www.evogene.com

35 www.evogene.com/news.asp

36 www.evogene.com

37 Evogene, "Monsanto and Evogene Collaborate on Nitrogen Use Efficiency Research," News release, 25 September 2007. Available online at: www.evogene.com/news.asp?new_id=45

38 Monsanto/BASF, "BASF and Monsanto Announce R&D and Commercialization Collaboration Agreement in Plant Biotechnology," News release, 21 March 2007.

39 Products that emerge from the joint development will be commercialized by Monsanto. The companies have agreed to share profits associated with commercialized products, with Monsanto receiving 60 percent of net profits and BASF receiving 40 percent.

40 Slate Canon, "BASF, Monsanto expand collaboration," *Delta Farm Press*, 8 July 2010. Available online at: http://blog.deltafarmpress.com/briefingroom/2010/07/08/basf-monsanto-expand-collaboration/

41 Monsanto, "InterGrain and Monsanto Announce New Wheat Breeding Collaboration: Monsanto to share technology, germplasm with Australian breeding leader; makes equity investment," News release Aug 26, 2010. Available online at: http://monsanto.mediaroom.com/intergrain-monsanto-new-wheat-breeding-collaboration

42 Clifford Carlsen, "Investors plant $75M in Ceres," TheDeal.com, 27 September 2007.

43 Ibid.

44 Simon Varcoe, “Monsanto Confident over GM Venture,” *AGROW*, 27 November 2007. Available online at: www.agrow.com/biotech_news33.shtml

45 Ibid.

46 BASF, “BASF Plant Science and Monsanto to expand their collaboration in maximizing crop yield,” News release, July 7, 2010. Available online at : www.basf.com/group/pressrelease/P-10-350

47 Peter Eckes, President of BASF Plant Science, “A grounded approach to agricultural sustainability,” Media Summit, Chicago, Illinois (USA), 9 June 2010. Available online at : www.agro.basf.com/agr/AP-Internet/en/function/conversions:/publish/upload/news_room/peter-eckes-presentation-chicago.pdf

48 Carol Potera, “Blooming Biotech,” *Nature Biotechnology* 25, 963 - 965, 3 September 2007. Available online at: www.nature.com/nbt/journal/v25/n9/full/nbt0907-963.html

49 Personal communication with Eric Rey, CEO, Arcadia Biosciences, 17 September 2010.

50 Agrow, “Arcadia completes first field trial for drought-tolerant crops,” Agrow Agricultural Biotechnology News, Monday, 7 January 2008. Available online at: http://www.agrow.com/biotech_news39.shtml

51 R.M. Rivero et al., “Delayed leaf senescence induces extreme drought tolerance in a flowering plant,” *PNAS* 104 (49) 2007: 19631-19636.

52 UC Davis, “New Drought-tolerant Plants Offer Hope for Warming World,” News release, November 26, 2007. Available online at : www.news.ucdavis.edu/search/news_detail.lasso?id=8439. Delayed leaf senescence induces extreme drought tolerance in a flowering plant. *PNAS* 104 (49): 19631-19636. The gene is an enzyme in the hormone cytokinin biosynthetic pathway. The gene was isolated from the soil bacterium *Agrobacterium tumefaciens*, and has been known for a long time. Their innovation was to link this gene to a promoter that they isolated from common bean, Phaseoulus vulgaris. They claim that there were no delays in flowering, or other negative changes in the plants under normal conditions.

53 Ashok B. Sharma, “Arcadia, Mahyco in Commercial License Agreement,” *Financial Express***,** April 14, 2008. Available online at: www.financialexpress.com/news/Arcadia-Mahyco-in-commercial-license-agreement/296700/

54 David Hest, “Seeds for Global Warming,” *Farm Industry News*, January 1, 2008.

55 Syngenta, “2010 Half Year Analysts’ Call Script**,”** July 22th, 2010. Available online at: www.zeneca.com/en/investor_relations/pdf/07.22.2010%20Syngenta%20H1%20Script.pdf

56 Syngenta, “Syngenta Seeds, Inc. Launches Agrisure Artesian(TM) Technology, First Water-Optimized Technology for Corn Hybrids,” News release, July 27, 2010.

57 World Business Council for Sustainable Development, “Tackling Climate Change on the Ground,” WBCSD, Corporate Case Studies on Land Use and Climate Change, December 2009. Available online at: www.wbcsd.org/DocRoot/3Eg5u08N3UAYciRKcigo/Land%20Use_220310.pdf

58 Arcadia Biosciences, “Arcadia Biosciences and Chinese Province Agree to Establish Methods for Carbon Credit Trading Based on Nitrogen Use Efficient,” News release, 3 May 2007.

59 Environmental News Network, “Carbon Credits to be Used to Fund GM Food Crops,” 8 January 2008. Available online at: www.enn.com/agriculture/article/28856

60 Personal communication with Eric Rey, CEO, Arcadia Biosciences, 17 September 2010.

61 http://www.monsanto.com/responsibility/our_pledge/healthier_environment/carbon_sequestration.asp

62 USDA website, frequently asked questions about Biotech Yield Endorsement, October 9, 2007. http://www.rma.usda.gov/help/faq/bye.html

63 Carey Gillam, “Biotech companies race for drought-tolerant crops,” *Scientific American*, 13 January 2008.

64 See claim # 7 from US Patent No. 7,161,063: Transcription factor stress-related proteins and methods of use in plants.

65 ETC Group, "Dupont and Monsanto – 'Living in Sinergy,'" News release, 9 April 2002. Available online at: www.etcgroup.org/en/materials/publications.html?pub_id=215

66 According to the US PTO, the GenBank database (an annotated collection of all publicly available DNA sequences) contained 651,972,984 nucleotides in 1,021,211 sequences in 1996. By February 2006, the GenBank database contained 59,750,386,305 bases in 54,584,635 sequence records or about a ninety-one-fold increase in the number of nucleotides and about a fifty-four-fold increase in the number of sequences. (Today the figure exceeds 107,533,156,756 bases. See www.ncbi.nlm.nih.gov/genbank/).

67 http://www.ncbi.nlm.nih.gov/sites/genome

68 National Center for Biotechnology Information, "Plant Genomes Central – Genome Projects in Progress." NCBI website. Available online at: www.ncbi.nlm.nih.gov/genomes/PLANTS/PlantList.html#C_SEQ

69 National Center for Biotechnology Information, "Genome project." NCBI website. Available online at: www.ncbi.nlm.nih.gov/sites/entrez?db=genomeprjcmd=Retrievedopt=Overviewlist_uids=9512

70 ETC Group, "Syngenta – The Genome Giant?" Communiqué, January/February 2005. Available online at: www.etcgroup.org/upload/publication/73/01/com_syngenta_final.pdf

71 ETC Group, "DeCodeing the Clinton/Blair Announcement," Geno-Types, 26 March 2000. Available online at: www.etcgroup.org/upload/publication/332/01/geno_decoding.pdf

72 Patent Lens, "Technology Landscapes: Rice Genome Landscape," website. Available online at: www.patentlens.net/daisy/RiceGenome/3648.html

73 Patent Lens, "Technology Landscapes: Genome Coverage in Application and Patents by For-Profit Companies," website. Available online at: www.patentlens.net/daisy/RiceGenome/3662/3108.html

74 Patent Lens, "Technology Landscape: What is a bulk sequence application?" website. Available online at: www.patentlens.net/daisy/RiceGenome/3663/2806.html

75 United States Patent and Trademark Offices, OG Notices: 27 March 2007. Available online at: http://www.uspto.gov/web/offices/com/sol/og/2007/week13/patsequ.htm

76 Richard Van Noorden, "DNA patent ruling hinders Monsanto**,"** *Nature*, 9 July 2010. Available online at: www.nature.com/news/2010/090710/full/news.2010.345.html

77 *Monsanto Technology LLC v Cefetra BV and Others*, Case C-428/08.

78 Matthew Royle, "Purpose-Dependent Protection for DNA," *Genetic Engineering Biotechnology News*, September 1, 2010, p. 9.

79 Ibid.

80 Patent Lens, "Broadening Claim Language in Gene Patents." Op., cit.

81 United States Patent and Trademark Office, "242 Nucleotide and/or Amino Acid Sequence Disclosures in Patent Applicatons," website. Available online at: www.uspto.gov/web/offices/pac/mpep/documents/2400_2422.htm

82 Patent Lens, op. cit.

83 Ibid.

84 ETC Group, "REVOKED! Monsanto Monopoly Nixed in Munich," News release, 3 May 2007.

85 ETC Group, "Enola Patent Ruled Invalid: Haven't we Bean here before?" News release, 14 July 2009.

86 "Transcription factors" are used to activate cascades of genes that function together to enhance stress tolerance. Transcription factors refer to a class of genes that control the degree to which other genes in a cell are activated. Transcription factors recognize and bind to regions of DNA that have a specific sequence in the promoters of the genes they regulate.

87 From the patent application abstract, US 2009/0300980 A1 (patent application). Corn with transgenic insect protection traits utilized in combination with drought tolerance and/or reduced inputs particularly fertilizer.

88 "On average, only about one-third of new-drug applications submitted to the FDA are for new molecular entities. Most of the rest are either for reformulations or incremental modifications of existing drugs or for new "on-label" uses (additional health conditions for which an existing drug can be prescribed). None of those types of new drugs involve a new active ingredient, although firms must conduct clinical trials to gain FDA approval for new uses." Source: Congress of the United States, Congressional Budget Office, *Research and Development in the Pharmaceutical Industry*, October 2006, pp. 14-15. Available online at: www.cbo.gov/ftpdocs/76xx/doc7615/10-02-DrugR-D.pdf

89 CYMMT website, "Improved Maize for African Soils," www.cimmyt.org/en/projects/improved-maize-for-african-soils

90 USAID, "Global Development Alliance Supports Use of Biotechnology to Improve Indian Rice and Wheat Production," News Release, April, 8, 2009. Available online at: www.usaid.gov

91 CGIAR, "Intensified Research Effort Yields Climate-Resilient Agriculture to Blunt Impact of Global Warming, Prevent Widespread Hunger," News release, December 4, 2006. Available online at: www.cgiar.org

92 International Maize and Wheat Improvement Center: CIMMYT Annual Report, 2003-2004. Available online at: www.cimmyt.org/en/newsletter/120-2004/399-adding-value-for-development-cimmyt-annual-report-2003-2004

93 Rodomiro Ortiz, et al., "Overview on Crop Genetic Engineering for Drought-prone Environments," International Maize and Wheat Improvement Center (CIMMYT), Vol. 4, Issue 1 (proceedings from November 2007 Symposium on Climate Change and Agriculture held at the International Center for Research in Semi-Arid Tropics (ICRISAT) in Andhra Pradesh, India. Available online: www.icrisat.org/journal/SpecialProject/sp3.pdf

94 Ibid.

95 Ibid.

96 Ibid.

97 Statement of Mr. Gerald Steiner, Executive Vice President, Sustainability and Corporate Affairs, Monsanto Company, before the House Foreign Affairs Committee, July 20, 2010. Available on Monsanto's website: www.monsanto.com/newsviews/Pages/Feed-the-Future-Initiative.aspx

98 Elizabeth Gibney, "WIPO Scheme to give patents to poorest," *Research Fortnight*, 21 April 2010. Available online at: www.aatf-africa.org/userfiles/WIPO-scheme.pdf

99 Ibid.

100 There is no such thing as an international patent. In patent applications published by WIPO, the applicant designates PCT member countries where he/she reserves the right to file a patent under the original filing date, without having to go to the expense of filing in each country. (The applicant has a period of at least 20 months from the original filing date to file a patent application in a designated country.) In other words, the WIPO patent application serves as a "placeholder." To obtain a patent in any of the designated countries, however, the application must be filed in the national patent offices.

101 General News of Africa (GNA), "Experts urge Ghanaians to use and apply modern biotechnology," 26 August 2010. http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=189187. See also www.syngentafoundation.org/index.cfm?pageID=533

102 Ron Mittler and Eduardo Blumwald, D., "Genetic Engineering for Modern Agriculture: Challenges and Perspectives," *Annu. Rev. Plant Biol*. 2010. 61:443–624.

103 Monsanto's researchers report here, for example: Donald E. Nelson, et al., "Plant nuclear factor Y (NF-Y) B subunits confer drought tolerance and lead to improved corn yields on water-limited acres," *PNAS*, October 16, 2007. Australian government gives a more transparent analysis here: Gio Braidotti, "Scientists share keys to drought tolerance," Australian Government Grains Research  Development Corporation, *Ground Cover* Issue 72, Jan.-Feb. 2008.

104 Gio Braidotti, "Scientists share keys to drought tolerance," Australian Government Grains Research Development Corporation, *Ground Cover* Issue 72, Jan.-Feb. 2008.

105 Pooja Bhatnagar-Mathur, V. Vadez, Kiran Sharma, "Transgenic approaches for abiotic stress tolerance in plants: retrospect and prospects," *Plant Cell Reports*, 27(3), 2008, p. 411.

106 Andrew Pollack, "After Growth, Fortunes Turn for Monsanto," *New York Times*, 5 October 2010.

107 Ibid.

108 Scott Kilman, "Superweed Outbreak Triggers Arms Race," *Wall Street Journal,* 4 June 2010.

109 Ibid.

110 Email correspondence with David Mackill, IRRI. January 29, 2008.

111 See Ronald Laboratory (UC Davis) website: http://indica.ucdavis.edu/research/research-project-overviews/submergence_tolerance

112 See http://bayanihan.org/2010/10/07/irri-set-to-transfer-submarine-rice-gene-to-popular-rice-varieties-across-asia/ and http://www.ciat.cgiar.org/Newsroom/Documents/pdf_seminars/2010_01_26_A_Dobermann.pdf

113 Rice production in sub-Saharan Africa increased from 4.8 million hectares in 1987 to 8.5 million hectares in 2002. Reiner Wassmann and Achim Dobermann, "Climate Change Adaptation through Rice Production in Regions with High Poverty Levels," *Journal of SAT Agricultural Research*, Vol. 4, Issue 1, 2007. Available online at: www.icrisat.org/journal/specialproject.htm

114 B. Manneh, et al., "Exploiting Partnerships in Research and Development to help African Rice Farmers cope with Climate Variability." *Journal of SAT Agricultural Research*, Vol. 4, Issue 1, 2007. Available online at: www.icrisat.org/journal/specialproject.htm

115 Ibid.

116 UNDP, *Human Development Report 2007/2008*, p. 107. Op. cit.

117 The four countries are Mozambique, Swaziland, Tanzania and Zimbabwe. FAO, "Diversity of Experiences: Understanding Change in Crop and Seed Diversity – A Review of Selected LinKS Studies," Gender Equity and Rural Employment Division, Rome, 2008.

118 Ibid., p. 12.

119 http://www.agassessment.org/docs/SR_Exec_Sum_210408_Final.htm

120 P. Jones, et. al., "Climate Proofing Agricultural Research Investments," Vol. 4, Issue 1 (proceedings from November 2007 Symposium on Climate Change and Agriculture held at the International Center for Research in Semi-Arid Tropics (ICRISAT) in Andhra Pradesh, India. Available online at: www.icrisat.org/Journal/symposiumv4i1.htm

121 FAO, "Diversity of Experiences: Understanding Change in Crop and Seed Diversity – A Review of Selected LinKS Studies," Gender Equity and Rural Employment Division, Rome, 2008.

122 For excellent examples from Southeast Asia, see: Rene Salazar, Niels P. Louwaars and Bert Visser, "On Protecting Farmers' New Varieties: New Approaches to Rights on Collective Innovations in Plant Genetic Resources," IFPRI, CAPRi Working Paper #45, January 2006. For findings from southern Africa, see: FAO, "Diversity of Experiences: Understanding Change in Crop and Seed Diversity – A Review of Selected LinKS Studies," Gender Equity and Rural Employment Division, Rome, 2008.

123 The example comes from Rene Salazar, Niels P. Louwaars and Bert Visser, "On Protecting Farmers' New Varieties: New Approaches to Rights on Collective Innovations in Plant Genetic Resources," IFPRI, CAPRi Working Paper #45, January 2006.

124 Ibid.

125 Wilhelmina R. Pelegrina, "Farmers' Contribution to Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture in Bhutan, Lao PDR, Philippines, Thailand and Vietnam." Unpublished paper produced by SEARICE for Informal Consultation on Farmers' Rights held in Lusaka, Zambia, September 18 – 20, 2007.

126 David B. Lobell, et al. "Prioritizing Climate Change Adaptation Needs for Food Security in 2030," *Science*, Vol. 319, 1 February 2008.

127 G. Galluzzi, P. Eyzaguirre and V. Negri "Home gardens: neglected hotspots of agro-biodiversity and cultural diversity," *Biodiversity Conservation*, published online 17 September 2010.

128 Ibid.

129 Ibid.

130 Zareen Bharucha and Jules Pretty, **"**The roles and values of wild foods in agricultural systems," Phil. Trans. R. Soc. B, September 27, 2010 365:2913-2926. Available online at: http://rstb.royalsocietypublishing.org/content/365/1554.toc

131 Ibid.

132 Ibid.

133 Navdanya/Research Foundation for Science, Technology and Ecology, "Biopiracy of climate resilient crops: gene giants steal farmers' innovation of drought resistant, flood resistant salt resistant varieties," New Delhi, India, 2009.

134 National Research Council of the National Academies, "Lost Crops of Africa: Volume II: Vegetables," National Academies Press, 2006. Available online at: www.nap.edu/openbook.php?record_id=11763

135 National Research Council of the National Academies, "Lost Crops of the Incas: Little-Known Plants of the Andes with Promise for Worldwide Cultivation," National Academies Press, 1989. Available online at: www.nap.edu/openbook.php?recoR&D_id=1398page=1

136 Subsidies are granted for some commodities and not to all farmers.

137 UNDP, *Human Development Report 2007/08*, p. 173. Op, cit.

138 A. Lane and A. Jarvis, "Changes in Climate will modify the Geography of Crop Suitability: Agricultural Biodiversity can help with Adaptation," *Journal of Semi-Arid Tropical Agricultural Research*, Vol. 4, Issue 1 (proceedings from November 2007 Symposium on Climate Change and Agriculture held at the International Center for Research in Semi-Arid Tropics (ICRISAT) in Andhra Pradesh, India. Available online: http://www.icrisat.org/Journal/symposiumv4i1.htm

# Capturing 'Climate Genes'

## Gene Giants Stockpile 'Climate-Ready' Patents

The world's largest agrochemical and seed corporations are filing sweeping patent claims for monopoly control over what they call 'climate ready' crops - engineered to withstand drought, heat, flooding etc. These patented techno-fix seeds will not provide the adaptation strategies that small farmers need to cope with climate change but will concentrate corporate power, drive up costs, inhibit independent research, and further undermine the rights of farmers. In this report ETC uncovers the scope of one of the broadest and potentially most dangerous patent grabs in intellectual property history.

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