Agricultural Biotechnology Council of Australia

# GM crops and climate change

**This information paper aims to explore the implications climate change may have on global agriculture and the role gene technology could play in contributing to climate change solutions.**

**Climate change and its current and potential impacts have an increasing profile globally. A growing number of countries are looking to implement policies and actions aimed at managing the impacts of climate change. In Australia, the Commonwealth Department of Climate Change and Energy Efficiency was established in 2007 to drive activities in this area.**

## Climate change in Australia

According to the Bureau of Meteorology (BOM), 'Australia and the globe are experiencing rapid climate change. Since the middle of the 20th century, Australian temperatures have, on average, risen by about one degree Celsius with an increase in the frequency of heatwaves and a decrease in the numbers of frosts and cold days. Rainfall patterns have also changed — the northwest has seen an increase in rainfall over the last 50 years while much of eastern Australia and the far southwest have experienced a decline.'

According to the State of the Climate 2012, compiled by the CSIRO and BOM:

- Australian annual average daily mean temperatures have increased by 0.9°C since 1910
- the main cause of the observed increase in carbon dioxide concentration in the atmosphere is the combustion of fossil fuels since the industrial revolution
- Australian average temperatures are projected to rise by 1.0 and 5.0°C by 2070 when compared with the climate of recent decades.

## Man's contribution to climate change

According to Climate Change in Australia, a Commonwealth Government website, the climate of earth changes continuously on a range of timescales due to 'internal' and 'external' factors. Internal factors are natural and arise from complex interactions within the climate system. Some of the external factors are also natural and include such things as volcanic eruptions.

Humans are also responsible for external factors which contribute to global warming, these factors include:

- changes in atmospheric composition (for example in concentrations of ozone, and the greenhouse gases, carbon dioxide, methane, nitrous oxide and chlorofluorocarbons)
- release of atmospheric particulates (such as sulfate aerosols and black carbon)
- modification of earth's ecosystems (including land clearing and agricultural practices).

## Climate change and agriculture

Of relevance to agriculture, some of the impacts of climate change projected for the coming century include:

- more heatwaves which will impact livestock, damage crops, and lead to an increase in bushfires
- warmer conditions which will increase the likelihood of pests and diseases from tropical and sub-tropical Australia spreading southward. Some weeds may benefit from climate change due to reduced competition from native species and perhaps crops
- fewer cold and frosty days which could impact some industries such as stonefruit where chilling would be inadequate
- more intense and sporadic rainfall (including from tropical cyclones) which would increase flooding and associated loss of life, property and productivity. It would also affect soil erosion and pollution of rivers and oceans
- more frequent or intense droughts which would increase loss of crops, livestock, fisheries and wildlife, and decrease river flows and water quality.

In 2005, the Australian Greenhouse Office commissioned *The Climate Change Risk and Vulnerability report*. This report identified agriculture as one of the sectors most vulnerable in Australia and noted that the impacts on individual sectors will vary depending on the sensitivity of the system and its adaptive capacity.

The report identifies the agribusiness units most at risk as those already stressed economically or biophysically, as a result of land degradation, salination and loss of biodiversity; those at the edge of their climate tolerance; and, those where large and long lived investments have been made, for example in dedicated irrigation systems, slow growing cultivars and processing facilities.

## Food security and climate change

All aspects of food security will likely be affected by climate change according to the Food and Agriculture Organisation of the United Nations (FAO), including:

- **Food availability (production and trade):** Climate change impacts on food production will be mixed and vary regionally. For instance, a reduction in the production potential of tropical developing countries, many of which are already faced with serious food insecurity, may add to the burden of these countries. Globally, the potential for food production is projected to increase with increases in local average temperature over a range of one to three degrees Celsius, but above this it is projected to decrease.
- **Food stability and access:** Food stability and access will be affected by changes in the patterns of extreme events, such as increased frequency and intensity of droughts and flooding. Food insecurity and loss of livelihood would be further exacerbated by the loss of cultivated land and nursery areas for fisheries through inundation and coastal erosion in low-lying areas.
- **Food utilisation:** The health consequences of climate change may also affect the way food is used in the future. For example, populations in water-scarce regions are likely to face decreased water availability, with implications for food processing and consumption; in coastal areas, the risk of flooding of human settlements may increase, from both sea level rise and increased heavy precipitation. This is likely to result in an increase in the number of people exposed to vector-borne diseases such as malaria and water-borne diseases such as cholera, thus lowering their capacity to utilise food effectively.

## Biotechnology, climate change and agriculture

According to the UN Intergovernmental Panel on Climate Change Working Group II report *Impacts, Adaptation and Vulnerability*, 'Breakthroughs in molecular genetic mapping of the plant genome have led to the identification of bio-markers that are closely linked to known resistance genes, such that their isolation is clearly feasible in the future. Two forms of stress resistance especially relevant to climate change are to drought and temperature. A number of studies have demonstrated genetic modifications to major crop species (for example, corn and soybeans) that increased their water-deficit tolerance, although this may not extend to the wider range of crop plants. Similarly, there are possibilities for enhanced resistance to pests and diseases, salinity and waterlogging, or for opportunities such as change in flowering times or enhanced responses to elevated $CO_2$.'

Gene technology, more specifically, is allowing scientists to further develop the basic science of genetics through gene discovery, and improved understanding of gene functions and interactions. This sets the foundation for the use of genetic markers to speed up plant breeding, the control of gene activity, and the modification and transfer of genes.

According to CSIRO, gene technology can help Australia's agricultural industries beat pests, diseases and weeds; understand flowering and seed formation; discover and silence genes; improve the nutritional traits of plants; develop plants as biofactories; and improve how plants perform in hostile environments.

## *Environmental benefits of GM crops*

In a report titled, *GM crops: global socio-economic and environmental impacts 1996–2010*, UK-based PG Economics concluded, 'crop biotechnology has contributed to significantly reducing the release of greenhouse gas emissions from agricultural practices. This results from less fuel use and additional soil carbon storage from reduced tillage with GM crops. In 2010, this was equivalent to removing 19.4 billion kg of carbon dioxide from the atmosphere or equal to removing 8.6 million cars from the road for one year.'

A further advantage of GM crops, according to the International Service for the Acquisition of Agri-biotech Applications (ISAAA), is that 'they can be modified faster than conventional crops — thus allowing implementation of a "speeding the breeding" strategy to meet the more rapid changes required by more frequent and severe changes associated with climate change.'

## *GM crops and climate change in Australia*

Climate change predictions for Australia are that much of the country may become hotter and drier. This means that farming practices in Australia's major cropping zones will need to adapt accordingly. Several GM crop trials are underway which have the potential to help producers deal with the impacts of climate change.

1. **Drought tolerant wheat:** Developed by the Victorian Department of Primary Industries, field trials of the GM drought tolerant wheat have been approved to take place near Horsham and Mildura in Victoria on a maximum total area of 0.4 hectares per year between June 2008 and March 2010. The trials aim to assess the agronomic performance of the GM wheat under rain-fed, drought prone field conditions. In order to increase the drought tolerance of the wheat, it has been modified to contain one of fifteen genes originally isolated from the plants thale cress and maize, a moss and a yeast.
2. **Drought tolerant wheat and barley:** Developed by University of Adelaide researchers, each of the GM wheat and barley lines will contain one of thirty five genes derived from plant sources (wheat, barley, maize or thale cress) or from moss or yeast. The introduced genes are intended to enhance survival and yield of the plants under stress conditions such as heat, cold or salt or to improve nitrogen, phosphorus or zinc uptake and utilisation. The trials will take place between 2010 and 2015.
3. **Drought tolerant sugarcane:** BSES Limited has also been licenced to undertake 'proof of concept' trials of GM sugarcane in Queensland. The GM sugarcane lines have been modified with 18 genes, either alone or in combination, to alter plant size and shape, enhance water use efficiency (WUE) or improve nitrogen use efficiency (NUE). The introduced genes are derived from rice, sugarcane, barley, bean, thale cress, apple, and maize.

Climate change presents challenges. Biotechnology and gene technology are tools which will contribute to climate change solutions. Australian agriculture will continue to adopt new technologies and innovations to ensure a sustainable and prosperous future.

## Further reading


Bureau of Meteorology: www.bom.gov.au.

*Climate Change and Water. 2008.* UN Intergovernmental Panel on Climate Change: www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf.

*Climate change: an Australian guide to the science and potential impacts. 2003.* Australian Greenhouse Office (now the Commonwealth Department of Climate Change and Energy Efficiency)

*Climate Change Risk and Vulnerability.* Promoting an efficient adaptation response in Australia. 2005. Report to the Australian Greenhouse Office, Department of the Environment and Heritage by the Allen Consulting Group: www.sfrpc.com/Climate%20Change/4.pdf.

Commonwealth Department of Climate Change and Energy Efficiency: www.climatechange.gov.au.

Table of applications and license for Dealings involving Intentional Release (DIR) into the environment, 2012. Office of the Gene Technology Regulator: www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/ir-1.

*GM crops: global socio-economic and environmental impacts 1996–2010.* 2012. PG Economics: www.pgeconomics.co.uk/page/33/global-impact-2012.

ISAAA Brief 43–2011: Executive Summary Global Status of Commercialised GM Crops: 2011, International Service for the Acquisition of Agri-biotech Applications: http://isaaa.org/resources/publications/briefs/43/executivesummary/default.asp.

*Impacts, Adaptation and Vulnerability*, Working Group II Report for the UN Intergovernmental Panel on Climate Change: www.ipcc.ch/ipccreports/ar4-wg2.htm.