CLIMATE CHANGE – HOW WILL IT AFFECT HOW AND WHERE WE GROW OUR CROPS ?

From an article in New Ag International, December 2005 by Bruce Knight

Most of the publicity and political discussion surrounding climate change relates to what measures could, or should, be taken to slow up global warming. Predictions on the impact of climate change on agricultural productivity on a global scale have been made by many international experts and most paint a negative picture. Some experts suggest that by the second half of the 21st century world food production could be severely at risk. But the story is far from simple. Indeed in some regions of the world, and for some crops, global warming will almost certainly bring about improvements in productivity and much of it in the next fifteen years.

Relatively little has been published outlining the impact from a business perspective and what will be the threats and opportunities for those industries that support the management of crops world-wide. To address this requirement a new agribusiness publishing organisation, Impact Reports, have produced their first strategic business report, running to 220 pages: *The Impact of Climate Change on Crop Production and Management – Now and in the Future.* Co-editor Bruce Knight outlines the main findings.

Climate change defined

A key contributor to the report was David Viner, from the Climatic Research Unit, Norwich. Together with colleague Craig Wallace, he set out the main characteristics of climate change recorded to date, and, based on the conclusions of the Inter-Governmental Panel on Climate Change, IPCC, scenarios for the future. He also covered the agricultural implications of climate change at national and international level.

The main facts are:

- The last 150 years has seen an unprecedented rise in global temperature at a rate of approximately 0.6°C per century.

- This has come about due to the increase in Greenhouse Gas (GHG), emissions particularly from CO_2.
- The distribution of rainfall precipitation has changed and the mean global sea level has risen.
- There is therefore no argument that we are experiencing climate change. Depending on what scenario is followed, the likely changes by the year 2100 are anticipated to be between 1.4-5.8°C increase in average global temperature and a rise in mean precipitation of between 1.3 and 6.8%.
- Weather patterns will be more varied and extreme events more common

Implications for agriculture

- A warming of northern Europe (especially during winter months) may lead to an increase in crop yields, due to both temperature increases and elevated CO_2 levels.
- In other parts of Europe, for the same reasons, most crops will benefit, although drier conditions in eastern and southern Europe, more akin to North African conditions, may be detrimental to crop growth.
- A similar northward trend will occur in North America
- Low latitude and tropical regions will suffer more drought conditions
- These effects will continue to come about during the first half of the century with some having an impact as early as 2020.

At a Royal Society conference in London in April, Steve Long, University of Illinois, published a paper, based on greenhouse trials. This indicated that the beneficial effect from raised CO_2 levels will be much less than had been predicted by the IPCC, and global food supplies could be under threat during the later decades of the 21st century. Not surprisingly the paper created debate amongst climatologists.

However, at the same conference Professor Martin Parry, Hadley Centre for Climate Prediction and Research, Meteorological Office, Exeter, who is co-chair of a working group within the Inter Governmental Panel on Climate Change, IPCC, tried to put Long's paper into context

Prof. Parry emphasised that the zones where crop yields, and therefore food supply, will be most vulnerable will be Africa, South Asia and the Middle East. He conceded that some of the earlier IPCC forecasts showing yield enhancements for the 21st century due to raised CO_2 levels can be questioned. However, *particularly in the northern hemisphere,* temperate regions there are likely to be gains up to the 2020s. Only later in the century, and this is far from clear, will the detrimental effects from drought and high temperatures take effect.

The fact that changes in climate may affect crop production has not gone unnoticed by a few Politicians. The UK's Minister in charge of the Department of The Environment, Food and Rural Affairs, Defra, The Rt Hon Margaret Beckett, gave the key-note speech at a conference in Exeter early in 2005 on the potential risks from climate change. She touched on the potential impact on British agriculture: " - *An increase in the risk of potential pests and diseases in agriculture due to warmer summers set against the potential for growing new crops such as sunflowers, navy beans, sweetcorn and biofuels"*

Extreme events

Apart from the gradual effects from global warming, most experts advise that weather patterns will become more unpredictable and that extreme events in the form of tropical storms, extreme periods of drought and flood producing rainfall will be more frequent. Dr Francesco Tubiello, Centre for Climate Systems Research, Columbia University, New York, has outlined in the report the consequent risks to crop production.

Weather events can be either localised or they may wipe out a crop regionally, causing farmers serious economic losses. There are a number of examples:

- Late frosts routinely prove damaging to coffee production in Brazil, or to orange crops in North Africa and Florida.
- Winter-kill of winter cereal crops are frequent damaging events in North America and northern Eurasia.
- Violent weather such as tornadoes and typhoons, hail storms and other heavy precipitation events can cause direct physical damage to crops.

Although extreme weather events are by definition short-term and unpredictable, they may be associated with large-scale variations in atmospheric circulation patterns, such the El Niño/La Niña semi-periodic cycles. For example, the El Niño of 1982-83 significantly increased the frequency of floods in Ecuador and northwestern Peru, adversely affecting food production systems in those countries.

- Floods in the USA

Damage to agricultural production due to excess precipitation events can be substantial. For example, the 1993 U.S. Midwest floods caused damages to farmers valued at about $6-8 billion. Crop losses, both above and below ground, occur because of anoxic conditions; increased risk of plant disease and insect infestation; and delayed planting or harvesting due to inability to operate machinery.

U.S. farmers typically turn to crop insurance and part of the insurance costs are borne by State and Federal governments. Private insurance firms often find the associated risks too unpredictable to insure at market prices. Total Federal disaster-related payments in the U.S. amounted to $119 billion over the period 1993-1997, while crop insurance losses grew 10-fold in recent decades.

- Heat waves in Europe

There is reasonable evidence to suggest that the occurrence of drastically different European summers such as observed in 2002 (very cold and wet) and 2003 (very hot and dry) can be linked to

global warming. A report by the European Union Joint Research Centre in Brussels revealed that the future heat wave patterns will bring about a drop in crop yields across southern and central Europe because of extensive droughts. In 2003, high temperatures and water shortages cut maize and sugar beet yields in Italy by 25%, and cereal yields by more than 30% in Austria, southern Germany, Hungary, Slovakia Romania and the Ukraine.

By contrast, crop yields rose in 2003 in northern European regions that were mainly unaffected by drought. This is in line with the prediction that agricultural productivity might increase in northern Europe under climate change, as the region becomes wetter. However, this does not take into account the possibility that wetter climates might be accompanied by increases in heavy precipitation events, leading to more frequent crop damage.

Managing variability in weather

- **for improved pest and disease control**

The increased variability of weather patterns is a key factor in the use of Decision Support Systems, DSSs, particularly in planning fungicide and insecticide applications for high value crops and in irrigation planning.

In his chapter, Howard Hinds, Plant Systems Ltd, Wisbech, described how access to reliable data by the use of in-field weather stations is supporting disease forecasting and fungicide application models for potato blight in Europe. In Canada, Colorado potato beetle incidence is modelled through DSSs. As a result of the greater weather variability, there will be an increased need for the use of DSSs. With no more than 20,000 weather stations in operation world wide, there is considerable opportunity for both commercial companies and Government Institutions to invest in wider application of DSSs.

Using weather forecast data to evaluate disease risk is more useful when applying protectant or contact fungicides, which make up the majority of fungicides in use. A weather forecast will give warning of on-coming disease risk periods and therefore allow crops to be protected ahead of spores landing on the crop. Because protectant fungicides have no curative activity they have traditionally been used over narrow time intervals, sometimes encouraging the over-use of agrochemicals. Integrating a weather forecast into a disease model thus allows for more timely application of protectant fungicides and therefore the potential to reduce the number of applications.

There is, therefore, an opportunity through the use of DDSs to optimise agrochemical use and to go some way to meet the demand of food retailers and consumers.

- **for irrigation scheduling**

Various models have been designed to estimate crop water demand and thus schedule irrigation. The two main weather-related components of irrigation schedules are rainfall and evapotranspiration (ET). In order to calculate ET, measurements of temperature, wind speed and global radiation are required. In its simplest form, an irrigation schedule will balance the inputs (rainfall/irrigation) with outputs (ET0). The balance sheet will then give a deficit figure if the output exceeds the input, which is usually referred to as a Soil Moisture Deficit (SMD). Once this deficit becomes critical to crop growth, an irrigation application can be triggered.

Irrigation scheduling is a cost-effective method of assessing the water demand of crops, however, for schedules to be accurate, local measurements of rainfall and ET are required.

In the EU, legislation is now in place (Directive 2000/60/EC) that will make it more difficult for growers to obtain licenses to abstract water.

A report by Downing, 2003, highlighted the possible scenarios and possible impacts of warmer drier summers on crop demand for water. By 2020 irrigation requirement for potatoes could be 46% higher than the present baseline.

How does climate change affect crop production?

Generally, effects of climate change are divided into two categories - direct and indirect effects.

- The direct effects, temperature and moisture levels, are most significant on crops such as wheat and soya beans (and rice), compared with for example maize or sorghum.

- The indirect effects of climate change on crop production efficiency are CO_2 levels and to a lesser extent UV intensity and ozone levels. CO_2 enrichment increases photosynthetic rates and water use efficiency. This applies to all types of crop.

The potential for crops to be adapted to meet climate change requirements is outlined, crop by crop in a chapter written by Dr Roger Turner, Romadest Associates. Generally there is still considerable genetic diversity for the plant breeders and biotechnologists to call on.

Research findings presented in the report also outlined examples of how important pests, diseases and weeds are already being affected by changes in climate.

Opportunities and Threats

The potential increase or decrease in crop yields, and the spread or decline in potential areas suitable for growing crops is presented in some detail in the report, looking at four geographic regions in Europe, USA, Canada and selected other parts of the world. However, in order for the benefits to be maximised and the risks to be minimised, a number of crop based industries will need to respond: Plant breeding, agrochemicals, fertilisers, irrigation and agricultural equipment.

Some of the more important trends, specifically caused by climate change, projected to 2020 are tabulated below:

CROP	**Main trends**	**Potential responses from industries**
Grain Maize	*N America*: Some yield increase with more heat units, expansion in Canada *Europe*: Yield increases and becoming established in NW Europe	*Varieties*: Short season varieties in North Drought resistance in South *Fertiliser:* Expanded demand in N *Irrigation*: Major demand in S. Scheduling management systems important
Wheat	*Europe and N America*: Overall average decline in yield, due to drought conditions in South. Increases in N Europe and Canada. Cropping areas spreading North	*Varieties*: Drought resistant in South Disease resistance in NW Europe *Fertiliser*: Greater N demand in North N run-off management important *Irrigation*: Major need in South
Soya Beans	*N America*: Some yield increase with more heat units, declining in South USA,expansion in Canada *Europe:* Some introduction in N.	*Varieties:* Short season varieties for Canada and N Europe *Irrigation*: Major demand in S. Scheduling management systems important *Equipmen*t: Minimum cultivation in USA
Rice	*Asia:* Lower yields in equatorial regions. Gains in North *Europe:* Slight gains in SE and SW	*Varieties*: New demand in India, C and N China *Equipment:* More mechanisation in China with multiple cropping
Sugar Beet	*N America:* Considerable yield increases, spreading into Canada *Europe:* Yield reduction in SW due to droughts, gain in NW	*Varieties*: New opportunities in USA/Canada. Drought resistance in S *Irrigation*: Demand in S. Management systems important

Potatoes	*N America:* Decline in yield in US, gains in Canada *Europe:* Yield increases in North in E and W. Production areas spreading North	*Varieties*: Drought resistant in S and C Europe and USA. Blight resistance important. *Irrigation*: Opportunities from Decision Support Systems.
Cotton	*N America:* Yield gains, increased area potential *Europe:* Yields under threat *Asia:* Increases in China	*Varieties:* Drought resistant varieties Bollworm resistance *Irrigation:* Increased potential in USA and Europe based on Decision Support Systems
Rapeseed /Canola	*N America:* Marginal change *Europe:* Yield increases in NW and Central regions.	*Varieties:* Consistent yield varieties for Canada. Drought resistance for S Europe *Equipment:*Minimum cultivation equipment in Canada and Europe

Some more important examples of how climate change is projected to affect pests and diseases are shown below. Generally weeds such as grass weeds in cereals, tend to follow the crop ie. the area affected expands or declines in proportion to the change in crop area.

Organism	**Europe**	**North America**
Western Corn Root Worm	Regular presence	Extension northwards
European Corn Borer	Some spread northwards	Increased frequency
Colorado Beetle	Extension to NW regions More generations	Wider spread
Late potato blight	Increase in North Decline in South	Marginal change
Wheat diseases	Disease balance changes	Some increase with milder winters
Sugar Beet Rhizomania	Spreads NW	Marginal spread
Vine Diseases	Downy Mildew spreads in N More Powdery Mildew in S	Downy Mildew increases

In conclusion

Many economic, political and technical factors will affect crop production yields, choice of crops regionally and how they are managed by 2020. Climate change will clearly be one of the most important factors. There are opportunities, and some threats, to most of the established organisations who rely on R & D to sustain their place in the market or who source and process food crops internationally. Furthermore, less predictable weather patterns will almost certainly bring about changes in the insurance sector. There is much scope for the wider adoption of weather based Decision Support Systems.

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