Past, Present and Future Climate-Agriculture Relations

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The Climate and Agriculture Connection

The connection between agriculture and climate in the Canadian Prairies is strong. Weather and climate can be a tremendous resource for agriculture, but it may also bring many hazards to agriculture. Finding the optimum combination of adaptation to climate is an important challenge for agriculture. Production per unit area has increased over time, mainly as a result of technologies. The major source of year to year deviation, both positive and negative, is due to climatic variability.

Past Global to Local Climates

Global air and sea surface temperatures have shown an increase of about $0.5°C$ over the past 100 years. This amount appears small, but in global and climatological terms, it is large and important. This trend seems to have accelerated recently, as many of the highest average yearly global temperatures have clustered in the 1980s and the 1990s.

A small change in global temperature translates into large changes for nations and for regions, and even larger changes at certain sites. Canada's climate has kept pace with global warming as its temperatures have increased by over $1\ °C$ in the past hundred years. Some of the most dramatic temperature changes in Canada, and perhaps the world, have occurred in the prairies.

Precipitation regimes are also changing. Although the yearly precipitation amounts for Canada are increasing, the trend for the prairies is downward over the past decades, with considerable variation. Prairie snowcover area has been affected most severely and has reduced considerably, especially over the past thirty years. Even larger and more rapid climatic changes are expected for the future, especially in mid-continental places such as the prairies. This has been termed the "ground zero effect" because the bulls-eyes of greatest projected change appears in the prairies.

Natural and Human Causes of Climate Change

There are many causes of climatic change, including both natural and human types. These include:

- solar energy related to changes in the sun's radiation and the earth's orbit;
- atmospheric particles related to pollution and volcanic activity, among others;
- reflectivity of the earth's surface (how bright it is);
- trace gases in the atmosphere that interact with the earth's heat budget (the greenhouse effect).

These factors act together in complex ways and at several different time and space scales. Some of them have a cooling effect, others have a warming effect; some can have either. Human activities have changed and are changing the earth's climates. The burning of fossil fuels, deforestation, and agricultural practices among many other human activities, add greenhouse gases to the atmosphere. The main greenhouse gases include carbon dioxide, methane, nitrous

oxide, and chlorofluorcarbons. The chemical composition of the atmosphere is quite different now than it was just a century ago because of these changes.

Modelling Future Climates

One of the best and perhaps only ways of exploring the effects of continued increases of greenhouse gases on Earth's climate is to use mathematical models. These General Circulation Models (GCMs) are simulations of the Earth's climate that we can pollute at will and measure how the climate changes. These models are based on the fundamental laws of physics and conservation of mass, momentum, and energy.

The results of the models at a time of doubled greenhouse gases in the atmosphere agree on several points:

- increased warming in higher latitudes, especially in winter;
- increased precipitation in higher latitudes and the tropics throughout the year, and in mid-latitudes in winter;
- increased drying across large areas of the northern mid-latitudes during the northern summer.

More confidence is placed in the results for the global scale and less for the local scale. Also, results for temperature are more certain than for precipitation. The ability to model regional climates is improving with the use of regional climate models. However, adjustments calculated from GCM results applied to historical data and sensitivity analyses are useful ways of examining climatic impacts and adaptations.

A panel of world experts on climate science (Intergovernmental Panel on Climate Change 1996) has recently stated that human impacts are now discernible in the climate record and that past climatic changes have not been caused entirely by natural variability. They write that future global warming or unprecedented amounts and rates is expected.

When the results are plotted for the Canadian Prairies, the temperature increases appear deceivingly small. The timing for these changes is estimated for about the middle of the next century. Winter average temperature increases are projected to be about 6 to 7°C across the agricultural regions; summer temperatures are expected to increase about 3 to 4°C. These winter temperatures are similar to those experienced during the incredibly warm "El Nino" winter of 1988 to 1989 when many sites had their first "brown" Christmas in many decades. Those projected summer temperature increases were much like those of the disastrous 1988 drought when daily highs pushed well over 40°C. The effects of those changes over a more frequent basis mean that much adaptation should take place.

Possible Effects or Why Should We be Concerned?

Future climatic changes related to the increase of atmospheric greenhouse gases and other factors have the potential to cause major impacts, both positive and negative, on regional and global agriculture. Future estimated changes in agroclimatic factors include:

- longer growing seasons;
- more frequent and extreme droughts and wet spells;
- more frequent and intense heat waves in summer, and fewer cold spells in winter;
- increased risk of soil erosion by wind and water;
- decreased snowcover area;
- decreased river flows and reservoir levels;

· decreasing air and water quality.

A changing climate affects agriculture through many paths, such as through effects on crops, pasture, soils, insects, weeds, diseases, and livestock. Most of the research estimating future climatic effects on agriculture have focussed on crop (mostly wheat) production. Crop yield effects vary considerably with several factors, such as both location, and climate and crop model. Generally, results are negative for wheat yields, except when very good adaptive measures or other assumptions are applied. It seems that the temperature increases advance maturity so strongly that yields are decreased. More frequent drought or flood years would also have a negative effect on yields, unless effective adaptive measures were put into place at the right times and places.

Adapting to Current and Future Climates

What can be done about the predicted future climatic warming? Much of the research that is already being done will support changes in management at the producer level to adapt to a warming climate. For example, introducing alternative crops such as chickpea, field pea and lentil which are drought tolerant or drought adapted, earlier seeding of such crops as canola (late fall seeding and very early spring seeding) which can then grow and complete a larger portion of the growth cycle before the heat and water stress periods occur, introducing warm season grasses and forage shrubs, breeding drought and heat tolerant wheats and wheats that are resistant to insects and disease, continued research into productions practices that increase water use efficiencies by conserving water (such as direct seeding into standing stubble that traps snow contributing to water conservation during winter and reduces evaporative losses of water during the growing season), developing decision support systems to aid producers and researchers in the decision making processes, developing production practices that can take advantage of longer growing seasons. Risk management may become a more important issue in the future as climate variability and the occurrance of climate extremes increase. It may be that for successful crop production in the future, producers may need to operate more on the risk fringe rather than from a place of risk adversion. And then again, maybe that is not all that different than from today.

Conclusions

Climate change is not a new phenomenon but one that has occurred throughout history. Climate change occurs over a spectrum of both time and space. Climate is highly variable and continually changing, and the driving forces behind these changes have both natural and human origins. A warming climate and earlier springs may have several implications for agriculture, especially with regards to the introduction of cool season crops such as field pea and with regards to the growth and production of forage crops. And yet, agriculture response to a warming climate is not clear. Agricultural productivity is dependent upon the combined actions of temperature and precipitation. For example, increased precipitation and enhanced early spring growth could more than compensate for hotter, drier summers. Estimating the impacts of climate change is still a new science, and because simulated results are not easily confirmed by experiment or by historical analysis, caution must be exercised when interpreting results. The need for judicious interpretation is emphasized by the marked differences in outcome from one scenario, impact model, or location to another.

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