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G02-1451 Climate Change and Winter Wheat: What Can We Expect in the Future?

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Climate Change and Winter Wheat: What Can We Expect in the Future?

This NebGuide will explain how climate changes at the end of this century will affect winter wheat production.

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Although it doesn't make daily headlines, global warming that results from climate changes will present challenges for current and future generations. While scientists may disagree about what causes current climate change, there is general agreement that a change is happening now and will continue for some time.

As humans, it doesn't matter much whether the air temperature is 92 degrees or 97 degrees - either way we tend to be uncomfortable. However, a 5 degree temperature change can have dramatic implications for plants, as well as an increase in carbon dioxide concentration.

About the Models

The idea for numerical weather prediction was developed at the end of World War I, but it wasn't until the arrival of the modern computer that it was put into practice. Eventually, the ideas developed in numerical weather prediction evolved into models to predict future global climates.

Two widely used models to predict future climates were developed at the Canadian Centre for Climate Modelling and Analysis and the United Kingdom Hadley Center for Climate Prediction and Research. The Hadley model results suggest milder temperatures and wetter conditions than the future climate projected by the Canadian model. These differences in projections are due to the different assumptions used in the models.

Climate Change

The climate change data (from the Hadley and Canadian models) represent projections for 2070 to 2099, and the current weather represents the years from 1980 to 1999. A sophisticated statistical technique was used to go from the course grid (~ 40,000 square miles) of these models to specific locations in

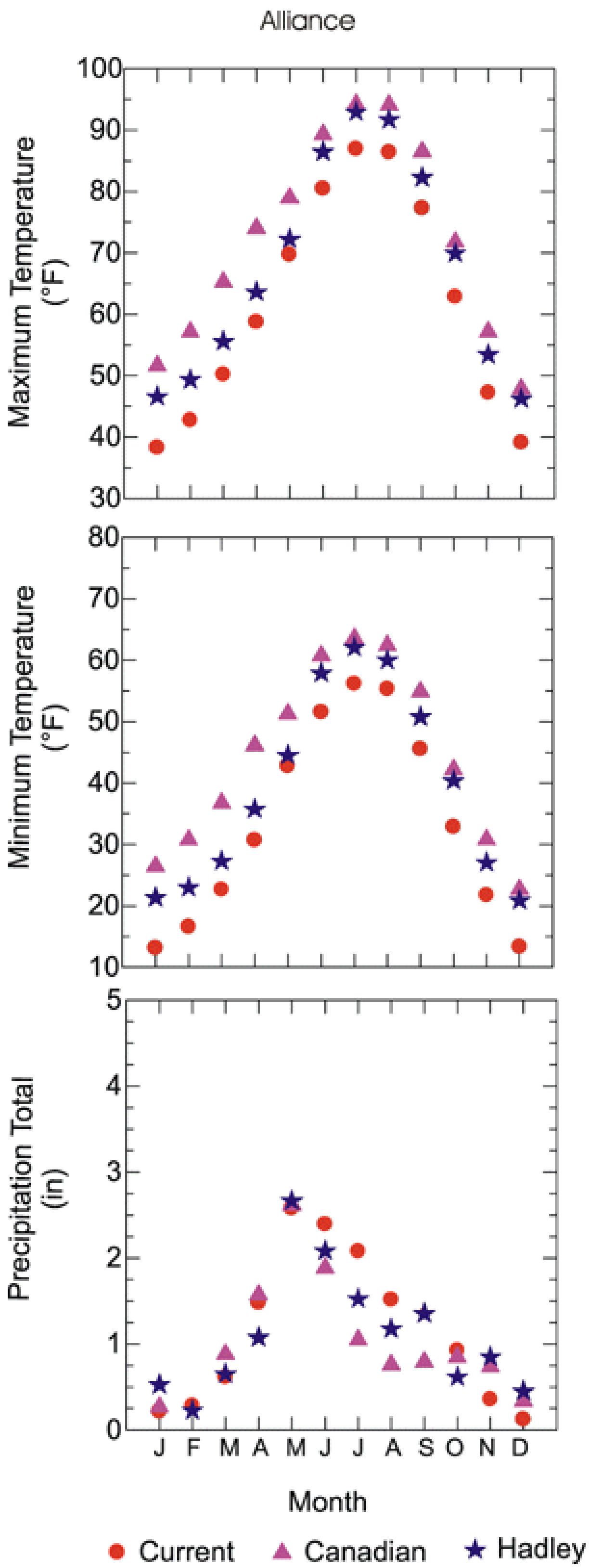
Nebraska. The locations used, which represent semiarid and subhumid climates, are Alliance in the Panhandle and the Havelock Farm of the Department of Agronomy and Horticulture in Lincoln, Neb.

Figures 1 and *2* illustrate the average monthly maximum and minimum temperatures and the average monthly total precipitation for Alliance and Havelock. The average monthly maximum and minimum temperatures follow the same general trend. The lowest temperatures are associated with the current weather, while the highest temperatures are projected from the Canadian model. Temperatures from the Hadley model generally lie between the current weather and the Canadian model. Temperatures from the Canadian model are projected to be about 8 to 15 degrees warmer than the current weather, while projections from the Hadley model are about 2 to 10 degrees warmer.

The total annual precipitation projected for Alliance decreases 2 inches, according to the Canadian model, and 1 inch according to the Hadley model, as compared to current precipitation. Currently, precipitation for July through September is 5 inches. The Canadian model predicts it will drop to 3 inches; the Hadley model, to 4 inches.

For Havelock, the total annual precipitation projection increases 2 inches according to the Canadian model and 5 inches according to the Hadley model. For the Havelock Farm, current precipitation for July through September is 10 inches. It's projected to either drop to 9 inches (Canadian model) or increase to 12 inches (Hadley model).

There was less than a 1-inch difference between precipitation projections from the models for the months between March and June.



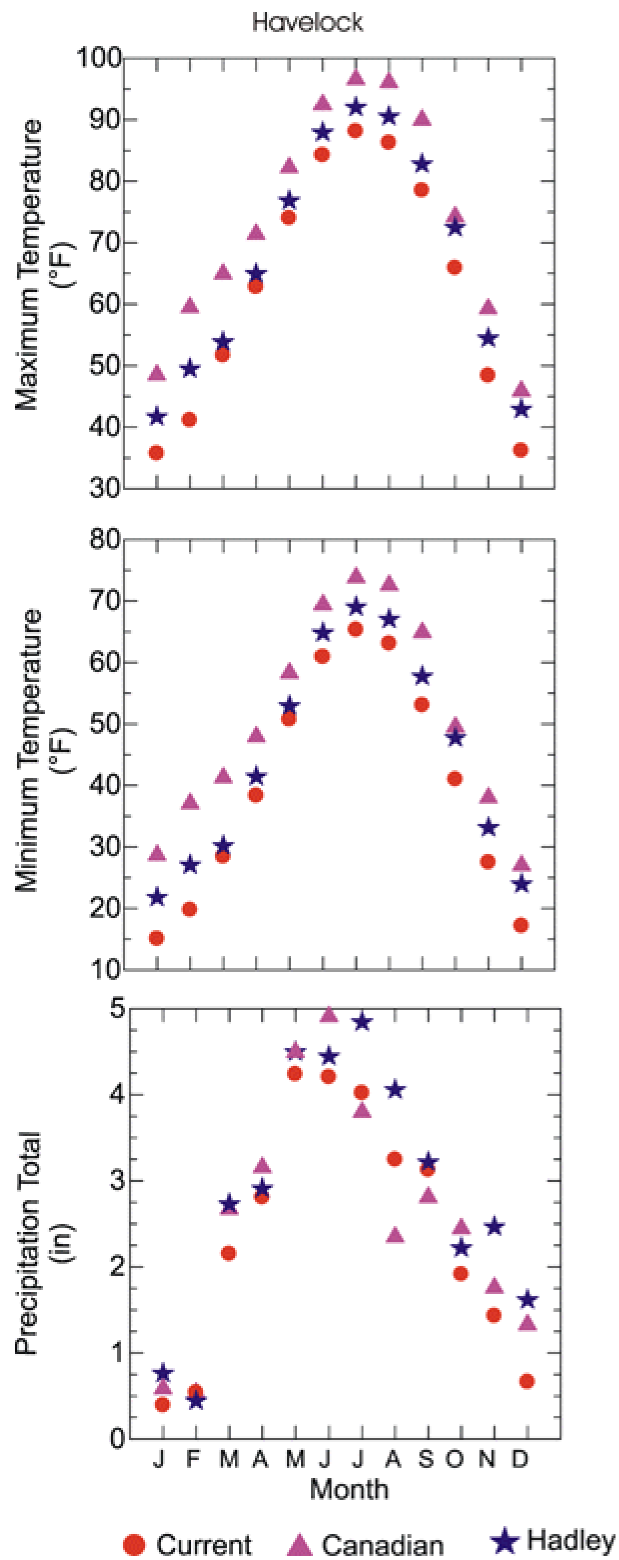


Figure 1. **Figure 2.**

Winter Wheat Simulations

A crop simulation model was used to project winter wheat yield and protein content at Alliance and

Havelock using projections from the two climate change models and a doubling of the current carbon dioxide concentration.

A crop simulation model uses information about the soil, daily weather and management practices to make projections of crop growth, development and yield. The crop simulation model used in this study, although state of the art, does not deal with the stresses caused by hail, high winds, insects, diseases or weeds. Thus, the results presented here represent optimal conditions without any stresses, except those caused by temperature, water and nitrogen. The model uses current weather (1980 to 1999) and projections from the Canadian and Hadley models (2070-2099).

Yield and protein content projections were made for two winter wheat cultivars, one currently grown in Nebraska ('Arapahoe') and one currently grown in Kansas ('Karl92'). 'Karl92' represents a cultivar that is adapted to a warmer climate such as the one that may occur with a climate change in Nebraska. We also projected the yields and protein content at two seeding dates: the date currently used and a later date. The later date represents an adaptation to a warmer climate. Seeding occurs later as a result of the warmer projected temperatures. We assumed a wheat-fallow rotation. It was also assumed in these simulations that 50 pounds per acre of nitrogen were applied at seeding.

Figures 3a and *4a* show that projected average yields from both the Canadian and Hadley models followed similar trends for both 'Arapahoe' and 'Karl92' at each location, although the trends differed at each location. For Alliance, both climate models projected a lower average yield for the current seeding date (S1 on the *Figures 3a* and *4a*) than for the later seeding date (S2 on the figures). Yields projected using current weather fall between the projected yields for the current and later seeding dates for both climate models. Using current weather, the projected average yields for `Arapahoe' were 43 bushels per acre and 38 bushels per acre for `Karl92'. At Havelock projected yields using current weather for 'Arapahoe' were 63 bushels per acre and 54 bushels per acre for `Karl92'. The yields projected for both seeding dates and both cultivars exceeded these projections, going as high as 80 bushels per acre for `Arapahoe' and 68 bushels per acre for `Karl92'.

The projected average yields for 'Karl92' are always lower than those for 'Arapahoe' at both locations for the same seeding date, regardless of the climate. This suggests that at Alliance a later seeding date could be an adaptation for climate change. *Figures 3b* and *4b* show the coefficient of variation (CV) of the projected yields. The CV measures variability, usually from 0 to 1; the higher the value, the more variability. For example, a value close to 0 means that yields for each year are almost the same, while a value close to 1 means a dramatic change in yields from year to year. If the CV is 1, yields can vary from 0 to double the average yield. In general the CV was twice as large at Alliance than at Havelock. At both locations, the changes in CV were similar for both cultivars and both climate model projections. Using a later seeding date (S2) will decrease the CV compared to using the current seeding date (S1) for both climate change projections.

These results imply that future yields at Alliance may be more variable than they are today with no adaptations, or as variable as they are today with the later seeding date. Opposite conditions hold true at Havelock. There is slightly more variability with projected yields using the current weather as compared to the two climate model projections. As premiums are paid for the protein content of the grain, projections of protein content are also important.

Figures 3c and *4c* show the projected average percent protein content of the grain. For Alliance, average protein contents are projected to decrease 2 percent to 3 percent between the two seeding dates, while at Havelock they are projected to decrease 1 percent to 3 percent. At Alliance, the projected average protein contents using the current weather are the same as when using the current seeding date for both climate models. At Havelock, the projected average protein contents using the current weather are the same when using the current seeding date only for 'Karl92' and decrease 1 percent for 'Arapahoe'.

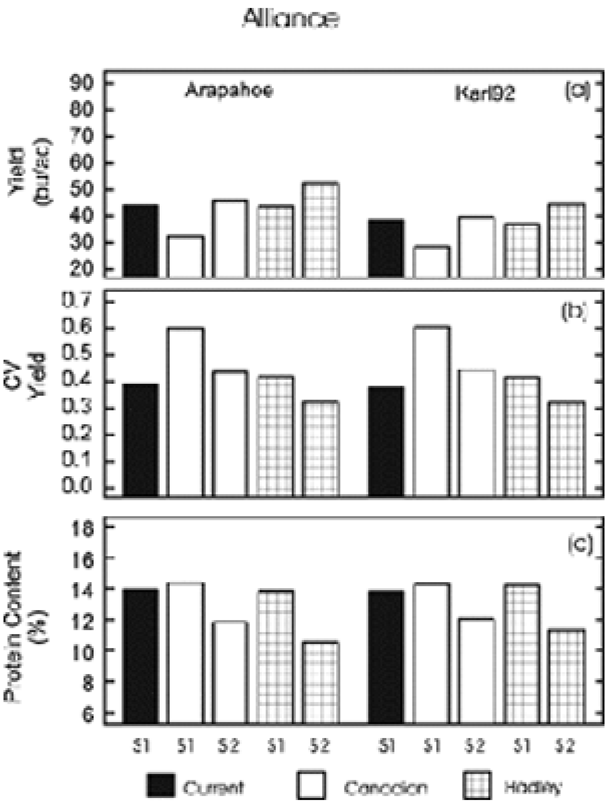


Figure 3. S1 is the current seeding date and S2 is a later seeding date that represents an adaptation to a warmer climate.

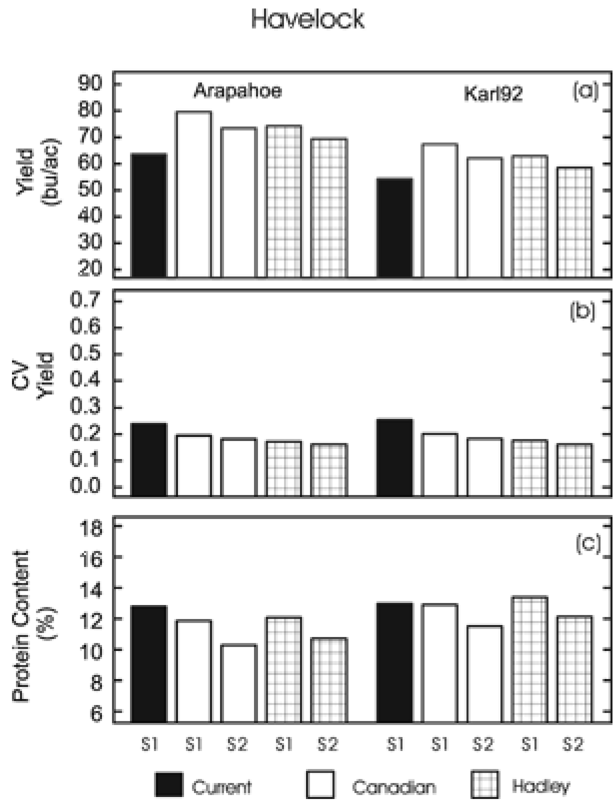


Figure 4. S1 is the current seeding date and S2 is a later seeding date that represents an adaptation to a warmer climate.

Conclusions

Some regions of the state will become less favorable and some more favorable for winter wheat production. The simple adaptations (a cultivar adapted to a warmer climate and a later seeding date) for the climate change models we have used cannot totally compensate for both losses of yield and protein content. Grain nitrogen is directly related to grain protein content. If the current grain protein levels and yields are to be maintained in future cultivars, these future cultivars will have to be more efficient in their abilities to take up nitrogen from the soil and to repartition it to the grain. Different nitrogen management strategies may have to be considered in the future, as well. The future will present us with both opportunities and challenges.

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