

Manitoba Not Yielding To Climate Change?

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***Abstract:** Using Manitoba Agricultural Services Corporation (MASC) production insurance data some recent trends in crop yields, yield variability, and losses in Manitoba are presented and discussed in an early climate change context. Manitoba yields have never been higher, nor less variable, than they have been in recent years. MASC loss experience has also not been outside of past ranges. These results suggest that early climate change has not negatively impacted crop yields in Manitoba.*

Introduction

Manitoba farmers know that vagaries of climate are the norm and the historical record documents many crop loss years resulting from extreme weather events. Management plays a part but annual weather variations, both within the growing season and in terms of extremes, are the main cause of crop yield variation. There is a general scientific consensus that climate change (warming) is occurring and that under climate change weather patterns may become more variable. In fact Manitoba, its location in the middle of a continent at higher latitudes, is likely to face earlier and more severe climate change than many other regions (Tyrchniewicz and Yusishen, 2000). It is known that crop yields will increase with more rainfall and decrease with higher temperatures. It is also known that in respect to crop yield variability, increases in rainfall will result in decreased variability and an increase in temperature will result in increased variability. With this strong relationship between weather and yields Manitoba farmers should expect that with climate change the mean and variance of crop yields will also change. How significant this change is and in what direction has yet to be determined.

Determination is challenging because of the relationship between climate and crop yield is complex (e.g. within season timing importance, offsetting between weather components, and ongoing changes in technology) and simple analysis could result in unrealistic crop yield impact estimates. For example in many crops precipitation is needed at the initial stages of production for germination, but less so during the final stages of production near harvest. To some extent the reverse is true for crops like potatoes and corn. Determining the impact of climate change on crop yields is important because the key to successful crop production in Manitoba is predictability – climate change could be reducing that predictability.

From a purely theoretical stand point if the weather becomes warmer and more variable then there should be an increased probability of high and low weather extremes such as illustrated in Figure 1. Significant consequences on crop yields are to be expected with any increased variation in temperature (drought, frost), precipitation type (rain, snow, hail), timing, frequency, and intensity, along with changes in wind (windstorms, tornadoes). Particularly in the early stages of climate change it is speculated that the greatest yield impacts are likely to come from changes in the duration, frequency and intensity of seasonal and extreme weather events within any year and not simply changes in mean temperature and precipitation.

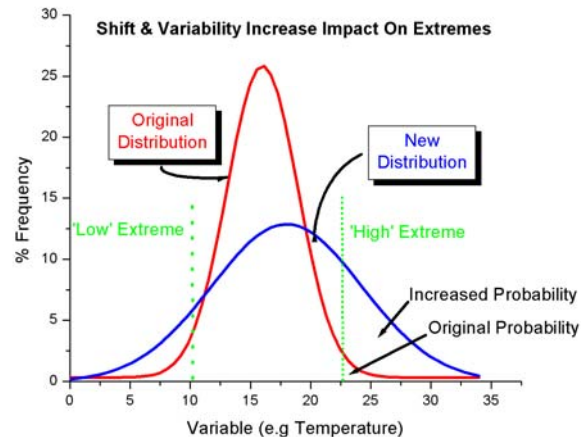


Figure 1 - A theoretical illustration of the increased frequency of extreme events with an increase in magnitude and variation of a variable.

The climate change models for Manitoba generally predict that under climate change (warming) farms could experience longer, warmer and drier summers, with greater potential for precipitation in the spring and winter (Tyrchniewicz and Yusishen, 2000). As a result climate change is expected to be a mixed blessing for Manitoba farmers – generally any benefits of a longer growing season are expected to be offset by harsher conditions brought on by weather extremes. More spring precipitation could mean ample moisture for germination but it could also mean more frequent floods. Drier summers could mean an increased risk of drought but it could also enable more farmers and regions to grow heat loving crops like corn, soybeans, and sunflowers. Milder winter temperatures could increase the survivorship of winter cereals but could also increase the over winter survival of harmful insects and plant diseases. Pesticides might also become less effective as temperatures rise. However, knowledge regarding most likely shifts in crop yields and in the frequencies of extreme events under a new climate regime is limited and purely speculative at this time.

The fundamental point is that the climate is changing and Manitoba farmers will need to manage its impact on crop yields. There is clear evidence of early stage climate change in the weather record. The question is whether there is early evidence for climate change in the Manitoba crop yield record? An answer is important because in order to determine how Manitoba farmers should adapt to climate change it is necessary to estimate the impact of climate change on crop yields.

Manitoba Average Yields

The Manitoba Agricultural Services Corporation (MASC) has collected yield data from its production insurance clients for over 40 years. Analysis of this data should show any yield trends and reveal if there is evidence of any climate change impacts on yields in recent years.

Figures 2 and 3 are plots of the average annual yields for selected crops since 1966 in Manitoba. Figure 2 illustrates the yields from the cereal crops wheat, barley, oat and corn and Figure 3 illustrates the yields from the broadleaf crops canola, flax, sunflower, and pea. Any outliers were removed using a 1.5 IQR technique. A trend line was plotted through the data. Each point on the trend line represents the average yield for the previous ten years.

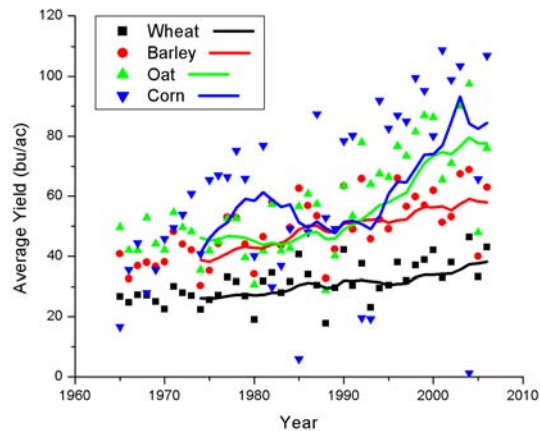


Figure 2 - Graph of the yields and yield trends for several selected cereal crops (red spring wheat, barley, oat, and corn) grown in Manitoba over the period 1966 to 2006.

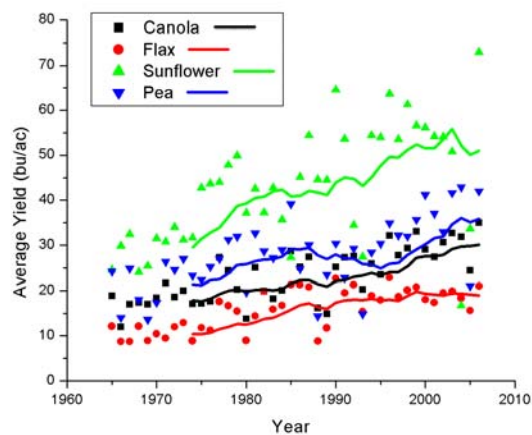


Figure 3 - Graph of the yields and yield trends for several broadleaf crops (canola, flax, sunflower, and pea) grown in Manitoba over the period 1966 to 2006.

Based on a non-statistical analysis of the trend lines there is nothing distinct about the yields or yield trends in recent years that I would attribute to climate change. Overall crop yields are generally higher in recent years but this is not inconsistent with historical trends. Additionally, there is no sudden jumps or drops in recent years that could be an indicator of climate change. Recent increases in yields could be due to climate change but in my opinion I would think a more reasonable explanation would be ongoing technological advancements.

Manitoba Yield Variability

Climate variability should lead to increased crop yield variation. Statisticians typically rely on variance or standard deviation as a measure of variability. However these statistics can be difficult to interpret without knowing the level or magnitude of the underlying variable. Therefore an alternative statistic called the coefficient of variability (CV) is commonly used. The CV

statistic measures the ratio of the standard deviation of a variable relative to its mean. Figures 4 and 5 are plots of the yield CV for selected crops since 1966 in Manitoba. Figure 4 illustrates the annual yield CVs for the cereal crops wheat, barley, oat and corn and Figure 5 illustrates the annual yield CVs for the broadleaf crops canola, flax, sunflower, and pea. Any outliers were removed using a 1.5 IQR technique. A trend line was plotted through the data. Each point on the trend line represents an average for the previous ten years.

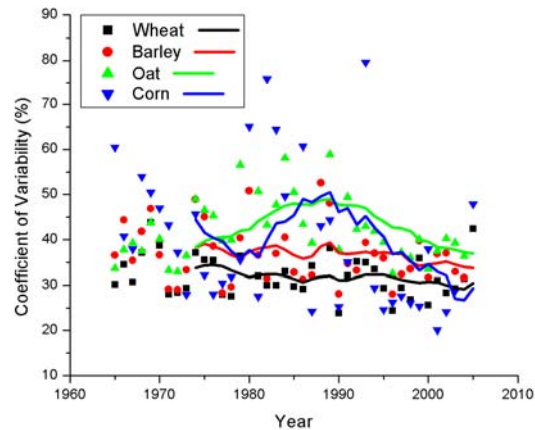


Figure 4 - Graph of the yield coefficient of variability (CV) and yield CV trends for several selected cereal crops (red spring wheat, barley, oat, and corn) grown in Manitoba over the period 1966 to 2006.

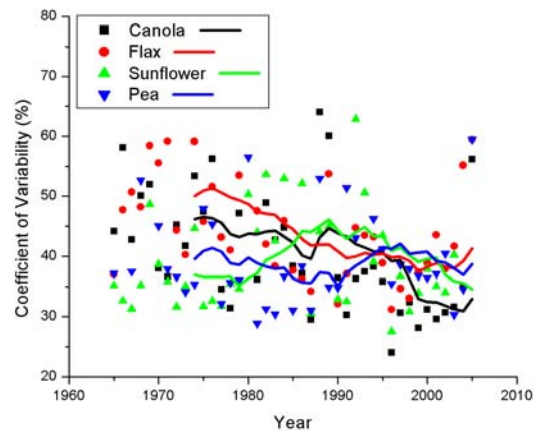


Figure 5 - Graph of the yield coefficient of variability (CV) and yield CV trends for several selected broadleaf crops (canola, flax, sunflower, and pea) grown in Manitoba over the period 1966 to 2006.

Based on a non-statistical analysis of the trend lines there is nothing distinct about the CVs or CV trends in recent years that I would attribute to climate change. Overall crop CVs are generally lower in recent years but this is not inconsistent with historical trends. Additionally, there is no sudden jumps or drops in recent years that could be an indicator of climate change. There is a minor recent jump in CVs for many of the crops but this is not inconsistent with jumps in the past. Generally CVs are trending down with current CVs being lower than ever. Low CVs mean lower yield variability which is inconsistent with the expectations of greater climate variability. In

my opinion the main cause of the lower CVs in recent years is ongoing technological advancements.

MASC Historical Loss Experience

All crops regularly suffer from stresses - weather is seldom normal and soil conditions are rarely optimal. Crop stress can be visually very obvious, or it can be so slight as to go unnoticed. At least until the yields come in. Additionally environmental variables which have limited adverse impact on their own can combine with other crop variables to result in severe adverse crop impact. Figure 6 illustrates the major historical causes of loss for MASC production insurance. From a production insurance perspective the major causes of loss in Manitoba over the period 1966 to 2005 have been drought and heat (35.4%), excess moisture (36.9%), frost (10.6%) and hail (7.7%).

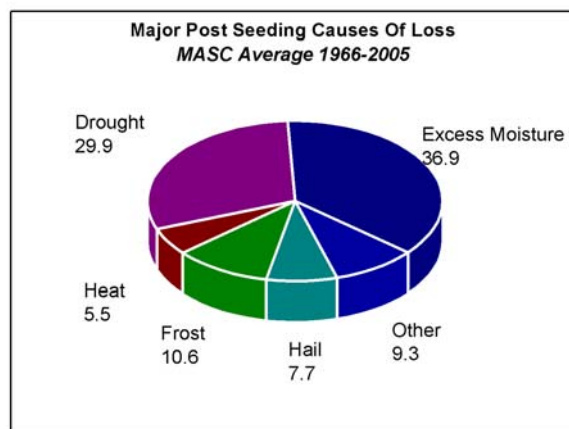


Figure 6 - Pie chart illustrating the relative percentage of the long term MASC production insurance losses by cause for the period 1966 to 2005.

Climate change is expected to increase the frequency of extreme weather. MASC production insurance tracks extreme weather impact on crops in Manitoba by tracking causes of loss associated with claims. If there is more extreme weather in recent years then that should be reflected in MASC claim cause of loss information.

Figures 7 to 10 are plots of the MASC cause of loss experience for four major causes of loss (excess moisture, drought, frost, and hail) for three selected crops (red spring wheat, canola, corn) since 1966 in Manitoba. To minimize the risk of confounding results with program design and demographic changes over time the cause of loss (COL) data was plotted by individual crop on a percentage basis. The y-axis is COL% which represents what percentage of MASC claims on that crop are attributable to that COL. Any outliers were removed using a 1.5 IQR technique. A trend line was plotted through the data. Each point on the trend line represents the five-year adjacent average percentage for each year.

Figure 7 illustrates MASC excess moisture loss percentages over time in selected crops. Under excess moisture conditions water logging of the root zone causes a lack of root aeration and a reduction in root oxygen leading to inadequate root growth and function and reducing yields. Based on a non-statistical analysis of the excess moisture loss trend lines there is nothing distinct about the trends in recent years that I would attribute to climate change. All three crops generally

follow the same trend – high excess moisture losses in the 1960s followed by a period of relatively low losses until a return to high excess moisture losses starting in the 1990s. It does however look like in recent years the year-to-year variability of excess moisture losses has increased but this was not investigated. The increased variability may be evidence of climate change or it could simply be evidence of technological improvements (more than in the past due to better farming technology you now either get a good crop or you don't get any crop at all).

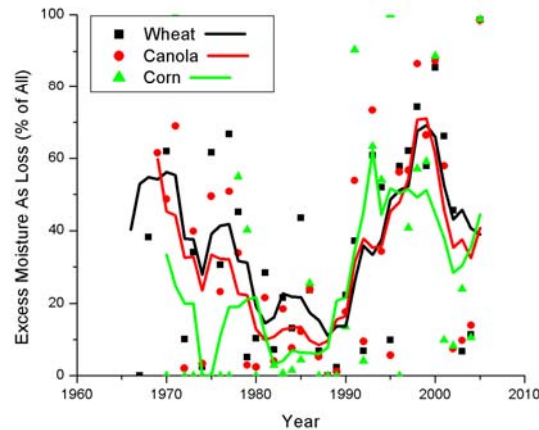


Figure 7 - Graph of the percentage of claims due to excess moisture losses and the associated five-year adjacent average trend lines for several selected crops (red spring wheat, canola, and corn) grown in Manitoba over the period 1966 to 2005.

Figure 8 illustrates MASC drought loss percentages over time in selected crops. Drought usually refers to a deficiency in available soil moisture which produces a water deficit in crops sufficient to cause a reduction in growth and yield. Based on a non-statistical analysis of the drought loss trend lines there is nothing distinct about the trends in recent years that I would attribute to climate change. All three crops generally follow the same trend – low drought losses in the 1960s followed by a period of relatively high drought losses until a return to low drought losses starting in the 1990s. As expected this trend is exactly the opposite of the excess moisture loss trends. There is no recent deviation that would suggest climate change is impacting crop yield losses.

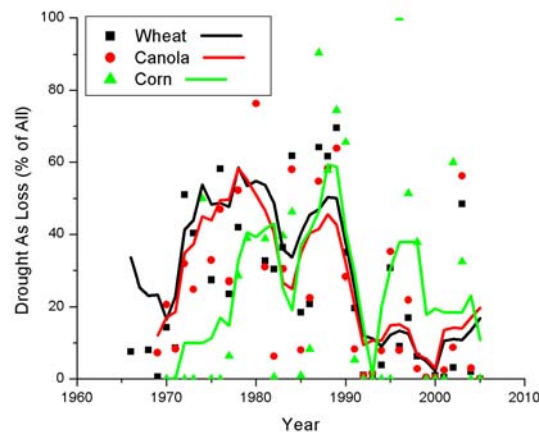


Figure 8 - Graph of the percentage of claims due to drought losses and the associated five-year adjacent average trend lines for several selected crops (red spring wheat, canola, and corn) grown in Manitoba over the period 1966 to 2005.

Figure 9 illustrates MASC frost loss percentages over time in selected crops. As a result of actual tissue freezing caused by frost plant parts or whole crops may be killed beyond recovery. The freezing damage is caused by ice crystals forming in cells and lacerating cell walls and/or desiccating cells and causing their collapse. Based on a non-statistical analysis of the frost loss trend lines there is nothing distinct about the trends in recent years that I would attribute to climate change. All three crops generally follow the same trend and in recent years frost losses have been trending upwards, perhaps returning to more historic levels. There is no recent deviation that would suggest climate change is impacting crop yield losses.

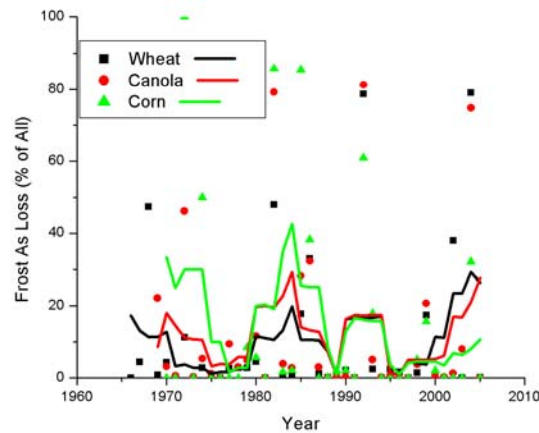


Figure 9 - Graph of the percentage of claims due to frost losses and the associated five-year adjacent average trend lines for several selected crops (red spring wheat, canola, and corn) grown in Manitoba over the period 1966 to 2005.

Figure 10 illustrates MASC hail loss percentages over time in selected crops. Yield losses from hail may be caused by loss of stand, leaf defoliation, basal tissue freezing and other secondary effects. Based on a non-statistical analysis of the hail loss trend lines there is nothing distinct about the trends in recent years that I would attribute to climate change. Unlike the other causes of loss the three crops generally do not follow the same loss trend – hail losses appear to be more independent. This may be an artifact of the more random and spotty nature of hail compared to the more widespread loss that tends to occur with losses from excess moisture, drought or hail. Hail losses in recent years have kept within historic ranges. There is no recent deviation that would suggest climate change is impacting crop yield losses.

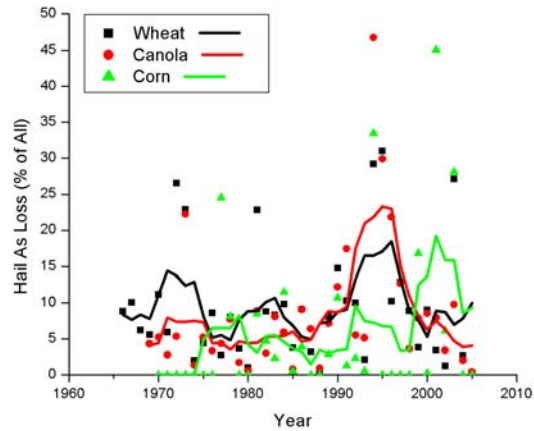


Figure 10 - Graph of the percentage of claims due to hail losses and the associated five-year adjacent average trend lines for several selected crops (red spring wheat, canola, and corn) grown in Manitoba over the period 1966 to 2005.

Loss Ratios

The loss ratio is a common measure of the operational performance of insurance products. It is simply the sum of all indemnities paid divided by the sum of all premiums collected. If the company has a loss ratio of greater than 100% then the company has lost money. If the loss ratio is less than 100% then the company has made money. If climate change is already happened then the expected loss ratios for MASC should be more frequent in recent years. Figure 11 is the calculated loss ratios for MASC production insurance in Manitoba since 1960. Based on a non-statistical analysis there appears to be no more losses in recent years than in the past. It is true that 2005 was one of the worst years on record for MASC losses but this could simply be explained as either an anomaly, or simply an artifact of recent program design and demographic changes – there is no evidence that it is a result of climate change. My observation is that not even MASC loss ratios are providing evidence of climate change.

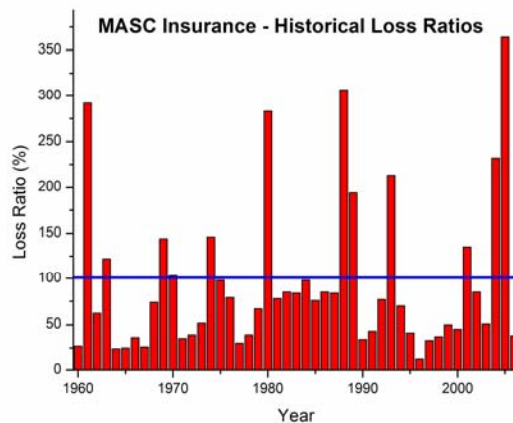


Figure 11 - Graph of the annual loss ratios (%) for MASC production insurance over the period 1960 to 2006.

Summary Remarks

Although in respect to crop yields and losses in Manitoba climate change appears to have had no significant observable impact to-date it is important to keep in mind the following quotation from William Cowper: *Absence of proof is not proof of absence*. Climate change is occurring - it just has not significantly impacted crop yields in Manitoba – yet.

Some might argue that the reason we can't see evidence of climate change in the Manitoba yield record is that producers are deliberately adapting to climate change. I agree that producers are adapting – but not specifically to climate change. The reality is that farming in Manitoba is influenced by many exogenous and endogenous forces. The exogenous forces (outside of a farmer's control) include the environment, government policy and economic conditions. The endogenous forces (that farmer's have some control over) include the farmer's experience, perceptions, location of the farm, and financing. Farmers make decisions based on consideration of all of these forces combined. Good luck to the researcher who wants to determine what percentage of a farmer's decision process to change management practices (e.g. plant new crops such as soybeans, plant herbicide resistant varieties, set-up better drainage, buy larger equipment, or apply newly developed fungicides) is a deliberate attempt to address climate change. My guess is that it will be a very small component of a farmer's decision process. It is also my opinion that it is largely only a fortuitous coincidence that the increase of these climate change adaptive processes are occurring during a time of climate change - helping producers to battle early climate change and even neutralizing it.

Adverse effects on crop yields from climate change can be reduced through successful adaptation. Some climate change adaptations include changing sowing dates, changing crop types and varieties, changing irrigation and drainage systems, changing to larger equipment, and changing to new generation pesticides. However, the fact that crop yields have never been better will put crop yield related adaptation by farmers at a disadvantage psychologically. Farmers will say yields have never been better so why should I adapt? Or they might say that the adaptations that I have already made (for economic or other reasons) are serving me well – why change? Producers want to be good environmental stewards, but they've got to meet their bottom line. This paper indicates that the impacts of early climate change on yields are relatively undetectable relative to the historic variability therefore relying on yield shifts to promote adaptation would not be wise. Farmers will only adapt in response to broadly changing conditions of agriculture as a whole, of which climate change is only one factor. A simple and widely applicable adaptation “prescription” is not likely. In my opinion any adaptation prescription will likely consider technological improvements, economics, and farm policy above climate change impacts. Since settlement, Manitoba farmers have had to adapt to changing markets, technology and transportation systems - they will now have to adapt to climate change.

Even though Manitoba is not yet yielding to climate change this should not lead to complacency. Current cropping practices have operated within a certain range of climate conditions not too different from "normal". As climate change continues to push the limits of this range unexpected significant disruptions may occur. New adaptive measures may extend this range slightly, but eventually one can hypothesize that eventually a tipping point will be reached beyond which adaptive activities will no longer be economically viable. When that tipping point is reached it will negatively impact crop production - yields will drop, yield variability will increase, and extremes in losses will be seen. To most effectively reduce the vulnerability of crops in Manitoba to the potential impacts of this tipping point, anticipatory adaptation will be necessary - even though it looks like clear combining now.

References

Tyrchniewicz, A. and Yusishen, B., 2000. Agriculture and Climate Change: Workshop Report, March 23, 2000. International Institute for Sustainable Development, Winnipeg. 15 pgs.