2023 Growing Season: How dry was it?
Yield loss from drought in three different cropping systems

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INTRODUCTION

Resilience to drought is important, especially in years such as 2021 and 2023 when precipitation was below average. The goal of this research was to determine how spring wheat grown in three different cropping systems responded to supplemental irrigation in 2023.
The research was conducted on the Glenlea long-term rotation, which was established in 1992. Glenlea compares the biological and economic differences of conventional and organic cropping systems. The two different four-year rotations within the experiment include 1) grain-only and 2) forage-grain.
The wheat in this experiment was grown in the forage-grain rotation, consisting of alfalfa-alfalfa-wheat-flax. Supplemental irrigation was added in three different management systems: conventional, organic with composted manure, and organic without composed manure. Composted manure is added to attend to a phosphorus deficiency (Stainsby, 2022); the untreated forage-grain organic plots (organic without composted manure) has not received supplemental nutrients for more than 32 years. This allowed us to compare irrigation response in P sufficient (organic with compost and conventional) and P deficient wheat crops. Supplemental irrigation aimed bring irrigated plots to the average amount of precipitation received in a growing season.

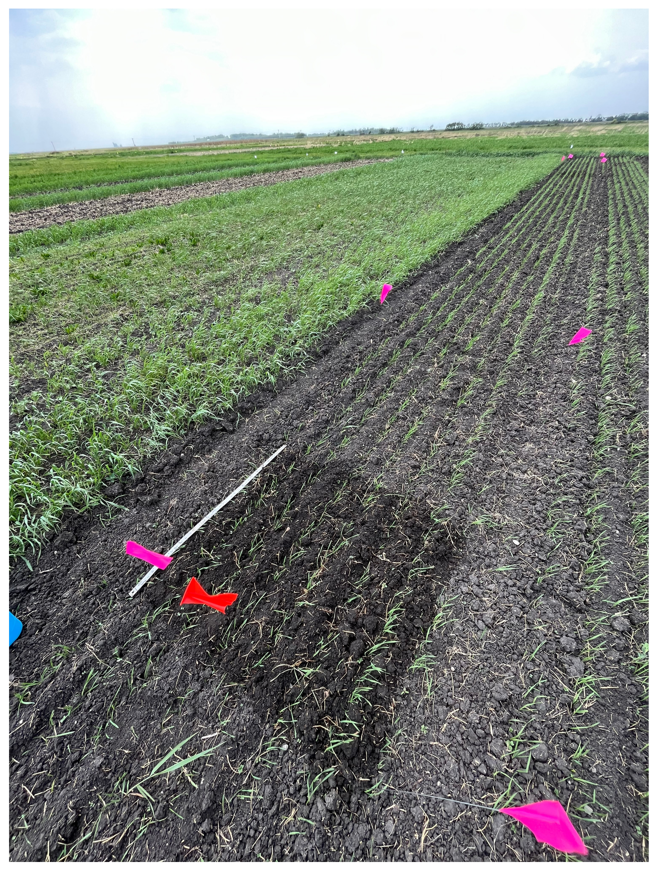

Figure 1. A 2 meter long irrigated plot within the larger wheat plot. 1 meter was watered at a time to ensure even watering.

METHODS

Spring wheat varieties differed for the organic and conventional treatments. In the conventional treatment, AAC Starbuck was grown while a farmer-selected line (HRE) was grown in both organic plots. The pedigree of HRE is described by Entz et al. (2018). Each treatment had three replicates.
Each subplot created for this experiment was within the main Glenlea plots and measured 2m by 1m. Within each replicate, each irrigated subplot had a corresponding non-irrigated subplot which served as a control. Irrigated subplots were first watered on May 29, and the final day of watering occurred on July 7. Irrigated subplots received 2 cm of supplemental water weekly, totalling 14cm over the duration of the growing season. A watering can with a pre-determined amount of water was used to control the amount of water that went onto the plots. To ensure that water distribution was even across a whole subplot, a meter stick was used to delineate one meter (Figure 1). Half the volume of water was distributed over the 1m x 1m area beside the meter stick, and the remaining half of the predetermined amount of water was dispensed on the remaining meter of the plot.
The response of wheat to water was determined using measures of biomass production, NDVI, plant height and grain yield. Biomass was first collected from both irrigated and non-irrigated subplots at flowering, taking 1.5 meters of 1 row from each subplot. Biomass samples were taken on July 6 in the conventional subplots and on July 10 in the organic subplots. Biomass for conventional and organic subplots was taken for a second time on August 16, where 2 meters of 2 rows were harvested, collecting 4 meters total from each subplot. This biomass was then threshed, weighed, and was used to determine final yield.
Plant height was taken by selecting three random areas within the subplot and measuring the height of a plant within the chosen spot. Plant height was taken three times throughout the growing season, on June 26, June 30 and August 13. NDVI was first taken on June 15 and continued to be taken until August 9. NDVI was done approximately two or three times a week. NDVI was no longer taken once spring wheat was mature and no longer green.

RESULTS

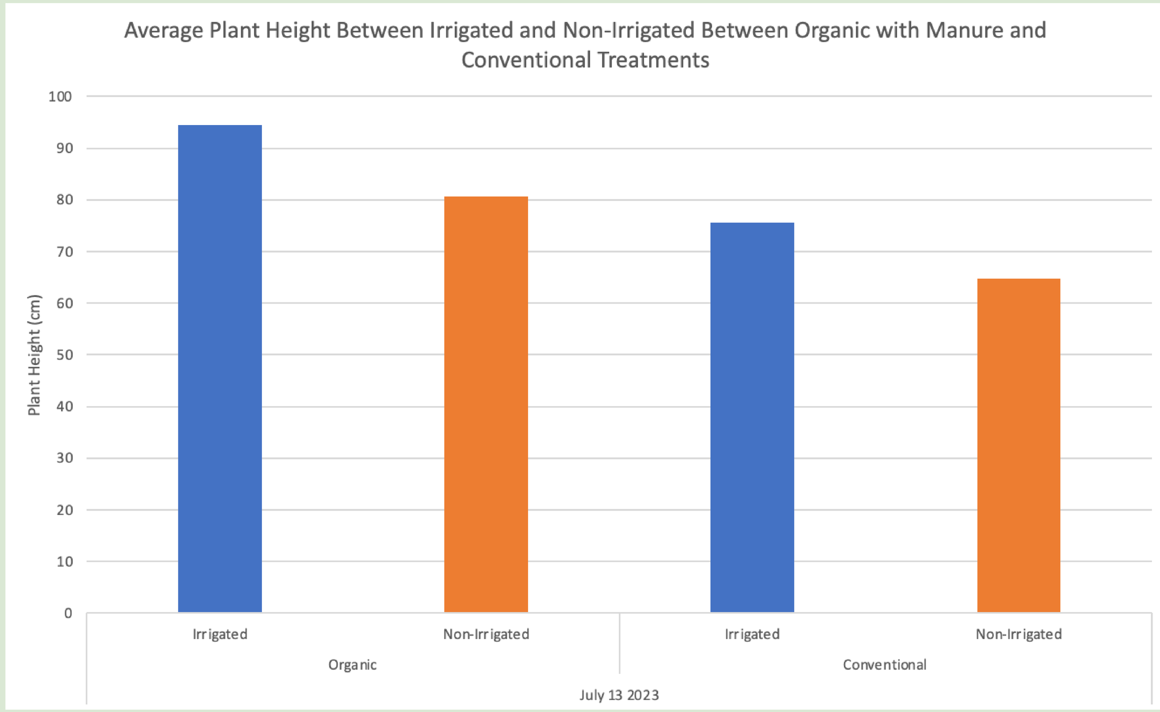

Figure 2. Average plant height (cm) of irrigated and non-irrigated spring wheat from organic with composted manure and conventional treatments on July 13, 2023.

Figure 3. A conventional irrigated plot (area within the pink flags) in which plants have a clear height difference in comparison to the non-irrigated surrounding plants.

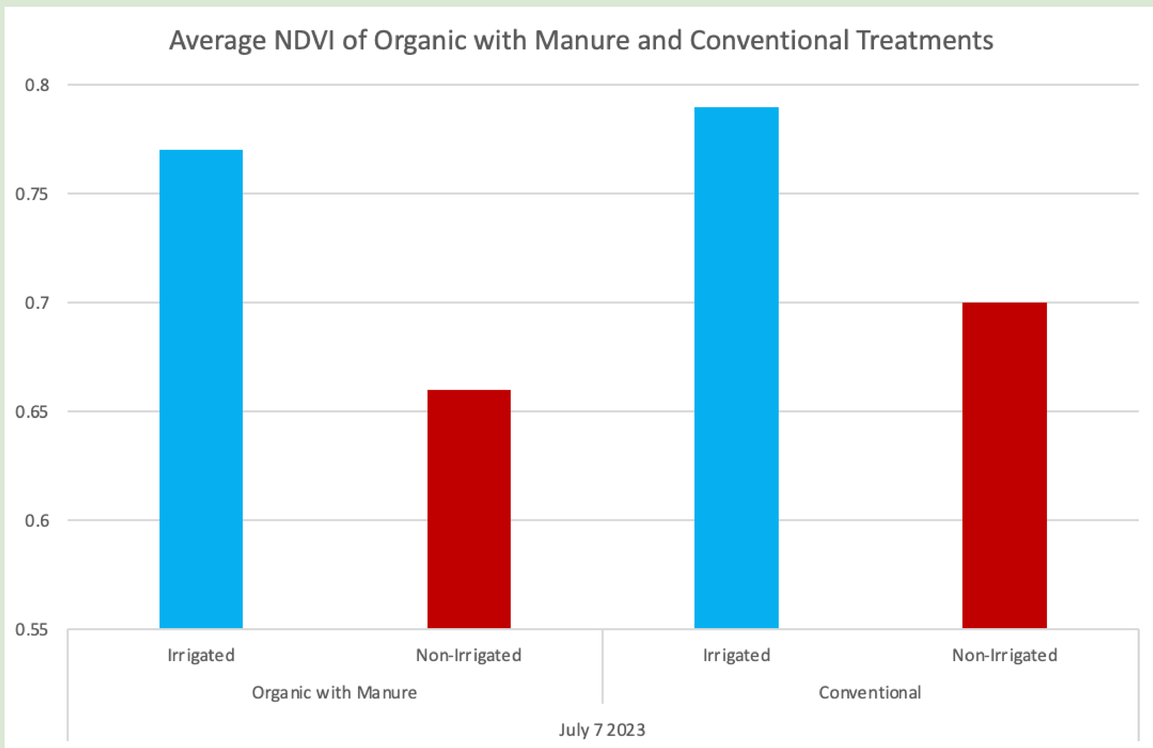

Figure 4. Average NDVI of irrigated and non-irrigated organic with manure and conventional treatments on July 7, 2023.

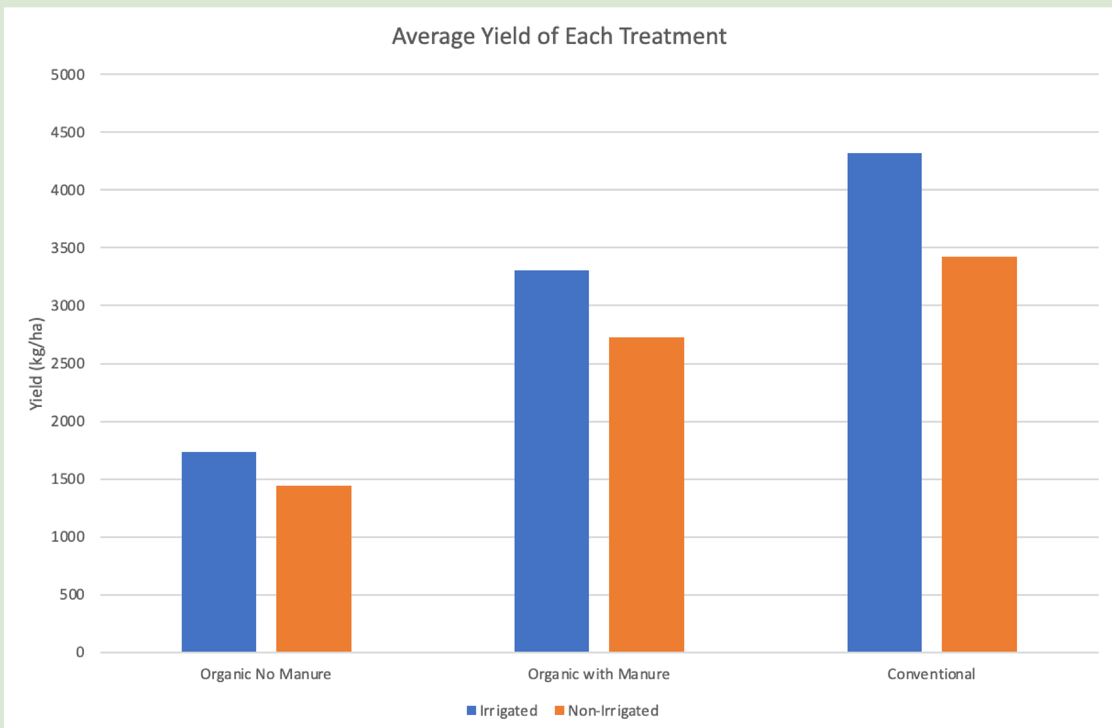

Figure 5. Average yields (kg/ha) of three treatments (organic without composted manure, organic with composted manure, and conventional.) Averages were taken across three replicates per treatment.

DISCUSSION AND CONCLUSION

On August 16, the organic with no composted manure treatment averaged 289.6g and 219.2g of biomass from the irrigated and non-irrigated plots, respectively. The organic with composted manure plots averaged 499.5g for irrigated and 370.4g for non-irrigated plots. Finally, the conventional plots averaged 506.2g and 398.5g in the irrigated and non-irrigated plots, respectively
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The irrigated organic with manure plots had the highest plant height on average with 94.5cm, and then 80.7cm in the non-irrigated plots (Figure 2). The conventional plots on average had plants with a height of 75.5cm in the irrigated plots, and 64.8cm in the non-irrigated plots. However, it is worth noting that the conventional variety grown, AAC Starbuck, is a semi-dwarf (Figure 3). The organic without composted manure treatment had an average plant height of 74.0cm in the irrigated plots and 73.2cm in the non-irrigated plots.

On July 7, the organic without composted manure treatment had an average NDVI of 0.74 and 0.61 in the irrigated and non-irrigated plots, respectively. The organic with composted manure treatment had an average NDVI of 0.77 in the irrigated plots and 0.66 in the non-irrigated plots. Finally, the conventional irrigated plots had an average NDVI of 0.79 and the non-irrigated plots had an average NDVI of 0.70 (Figure 4).

The organic with no manure treatment yielded the least in both the irrigated (1737 kg/ha) and non-irrigated plots (1442 kg/ha). This could be attributed to the fact that the unmanured organic plots have a phosphorus deficiency (Stainsby & Entz, 2022). The organic with manure treatment on average yielded 3308 kg/ha in the irrigated plots, and 2726 kg/ha in the non-irrigated plots. Finally, the conventional treatment yielded 4318 kg/ha in the irrigated subplots, and 3422 kg/ha in the non-irrigated plots (Figure 5).
The differences in yield between the irrigated and non-irrigated organic no manure, organic with manure, and conventional plots were 294 kg/ha, 582 kg/ha, and 895 kg/ha, respectively.

Through supplemental irrigation, wheat yields were increased from 20% to 26%. This suggests that in the Glenlea region of Manitoba, wheat yields were 20 to 26% lower than if the "normal" amount of growing season precipitation would have been received. In future, such in-field measures of "water resilience" may be helpful to track the effects of climate change on wheat yields in the region. Agronomists may want to consider conducting "water resilience" testing on commercial fields.

Both the conventional and organic with composted manure treatments were responsive to supplemental water, due to their adequate access to P. The organic without composted manure treatment was the least responsive to irrigation, which demonstrates the importance of adequate nutrient supply and clearly demonstrates that nutrient limitations were more serious than water shortages for the unfertilized organic plots.

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