



## Introduction

- Grain drying is essential for maintaining food quality, safety, and nutritional value after harvest.
- In-bin near-ambient drying** is a widely used, energy-efficient method across the Canadian Prairies.
- Its effectiveness depends on **weather variability**, **initial grain moisture**, **airflow rate**, **harvest date** and **fan control strategy**.
- Inefficient fan control can lead to **overdrying**, **insufficient drying**, or **spoilage**, affecting **grain quality** and **storage stability**.
- There is a need to optimize fan operation using long-term weather data and modeling tools.
- This research combines **traditional drying practices** with **modern simulation** and **decision-support** techniques to enhance food quality and sustainability.

## Objectives

- To simulate in-bin natural air drying of **wheat**, **barley** and **canola** under Prairie weather conditions.
- To evaluate fan control strategies based on **fan hours**, **success rate** and **moisture spread**.
- To develop a **nomogram** to guide fan control and predict drying performance.

## Methodology

- Modeling Tool:** Simulations conducted using IntegrisPro (OPIsystems Inc.©) modeling software.
- Study Region:** 15 locations across the Canadian Prairies representing diverse climatic conditions.
- Weather Data:** 35 years (1990–2024) of hourly historical weather data used to capture seasonal variability.
- Grain Types:** Wheat, Barley and Canola.
- Variables Tested:**
  - Initial grain moisture content (IMC)
  - Airflow rate ( $m^3/min/t$ )
  - Harvest date or Drying start date
  - Fan control strategy (Fan ON, NAD, NADH)
- Simulation Outputs:**
  - Fan hours usage
  - Drying success rate
  - Percent overdrying or moisture spread
- Results will support nomogram development for fan control decision-making.

## Observations

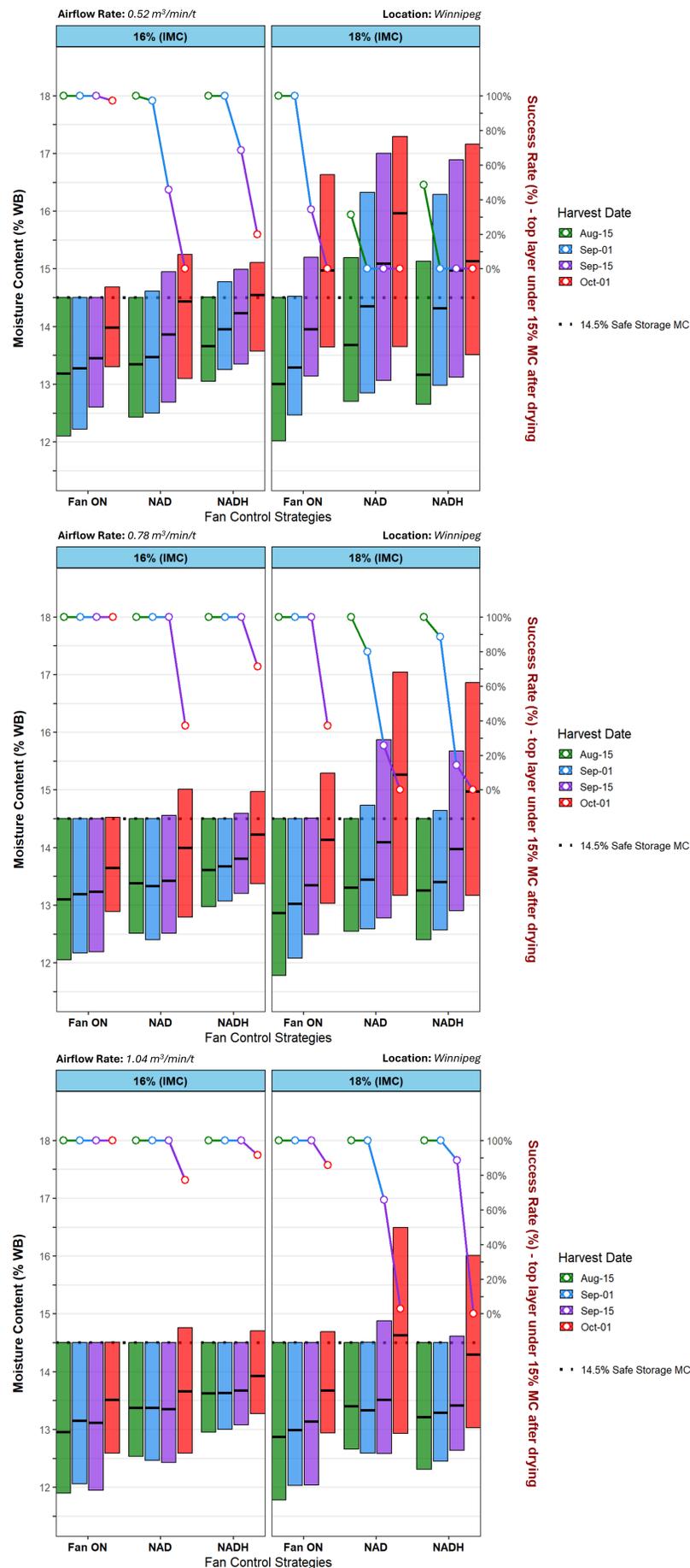


Figure 1: Moisture spread within the bin and success rate after drying.

## Conclusion

- The simulation results show that **initial grain moisture**, **airflow rate**, **drying start date**, **weather conditions** and **control strategies** highly influence in-bin near-ambient drying of wheat.
- High-moisture wheat (18%)** required **early harvest** (before Sept 15) and **high airflow rates** ( $0.78-1.04 m^3/min/t$ ) for effective drying.
- Low airflow rates** ( $0.5 m^3/min/t$ ) performed well for **16% IMC**, even in **later harvests**, but consumed **longer fan hours**.
- Continuous fan operation** achieved high success but often caused **overdrying**.
- Automated controls (NAD, NADH)** improved **moisture uniformity** within the bin, and **adding heat (NADH)** further enhanced drying performance.

## Tables

Table 1: Fan hour consumption for different airflow rates, IMCs, harvest dates and fan control strategies.

Airflow Rates ( $m^3 min^{-1} t^{-1}$ )	IMC	Fan Control Strategies	Fan run time (h)			
			Harvest Dates			
			Aug-15	Sep-1	Sep-15	Oct-1
0.52	16%	Fan ON	849.2	890.4	1010.8	1023.8
		NAD	912.5	893.1	734.0	473.2
		NADH	1012.6	914.9	751.3	555.9
	18%	Fan ON	1303.7	1478.4	1453.5	1093.6
		NAD	1367.4	1082.3	828.5	527.9
		NADH	1316.1	1081.1	878.9	638.1
0.78	16%	Fan ON	572	594.8	666.1	784.5
		NAD	606.1	620.7	645.6	473.2
		NADH	686.6	718.3	730.6	555.9
	18%	Fan ON	857	922.6	1075.2	1067
		NAD	1024.5	1003.5	826.5	527.9
		NADH	934.6	1003.2	879.9	638.1
1.04	16%	Fan ON	434.1	454.1	501	579.8
		NAD	455.4	465.6	490.8	443.5
		NADH	515.8	526.5	559.1	550.8
	18%	Fan ON	634.9	675	777	912.3
		NAD	755.8	785.6	762.5	527.9
		NADH	676.8	735.9	794.6	638.1

Table 2: Heater hour consumption for different airflow rates, IMCs and harvest dates.

Airflow Rates ( $m^3 min^{-1} t^{-1}$ )	IMC	Fan Control Strategies	Heater run time (h)			
			Harvest Dates			
			Aug-15	Sep-1	Sep-15	Oct-1
0.52	16%	NADH	198.5	191.2	161.8	126.7
	18%	NADH	225.1	191.2	161.8	126.7
0.78	16%	NADH	121.7	140.1	190.1	126.7
	18%	NADH	141.8	174.1	161.8	126.7
1.04	16%	NADH	93.7	97.8	111.4	125.1
	18%	NADH	100.5	113.9	143	126.7

## References

- Singh, C.B., D.S. Jayas and R. Larson. 2014. Assessment of fan control strategies for in-bin natural air-drying of wheat in Western Canada. Canadian Biosystems Engineering / Le Genie Des Biosystems Au Canada 56(1): 3.25-3.36.
- Lawrence, N.J. and N.D.E. Maier. 2011. Aeration strategy simulations for wheat storage in the Sub-Tropical region of North India. Transactions of the ASABE 54(4): 1395-1405. <https://doi.org/10.13031/2013.39008>.

## Acknowledgement

