MANAGING STORED CORN IN THE HUMID TROPICS

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Purpose

The tropical climates create a far more challenging environment for stored corn than the temperate U.S. Midwest, with elevated risks of mold growth and insect infestation. Imported U.S. corn typically arrives at 14–14.5% moisture and is stored in cylindrical steel silos where grain and headspace temperature and relative humidity often reach levels highly favorable for fungal and insect activity. Under these conditions, proper aeration becomes essential to prevent physical and biological deterioration. This factsheet outlines how to use grain monitoring and ambient aeration strategies to keep stored corn in safe, stable conditions under humid tropical conditions.

Storage conditions for safe storage of corn

Several key factors determine whether grain deteriorates in storage: grain moisture content, temperature, initial quality, the amount and distribution of BCFM, and the presence of insect pests, molds, rodents, and birds (McNeill, 2017, MWPS-13). Aeration—using ambient air to control grain temperature and moisture migration—is one of the most important tools for maintaining grain quality.

In tropical climates, where ambient air cannot effectively cool grain, the goal of aeration shifts from cooling to equilibrium management: reducing moisture and RH stratification and preventing the formation of hotspots. Stored grain in warm, humid conditions is especially vulnerable to biological deterioration because temperatures often exceed 30°C and RH surpasses 70%. Storage fungi generally begin to grow when the equilibrium relative humidity (ERH) exceeds 65% (aw = 0.65). Figure 1 illustrates safe and unsafe storage zones for corn along moisture sorption isotherms at 60%, 65%, and 70% RH.

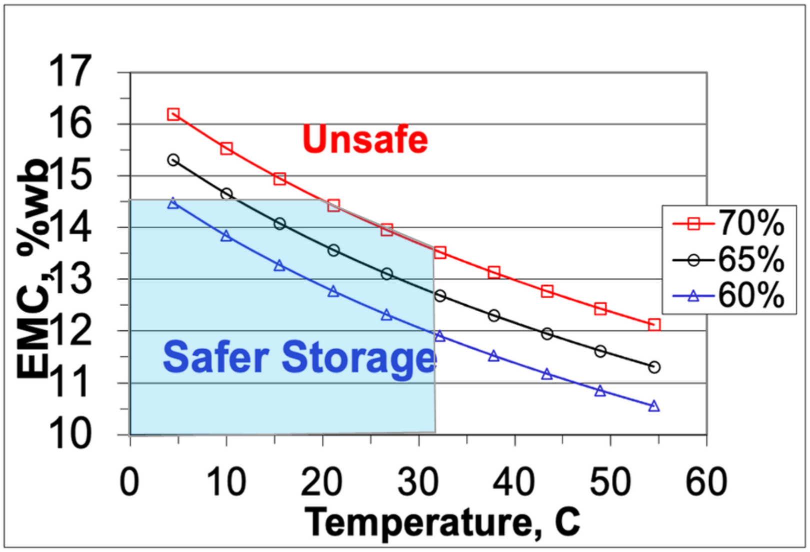

Figure 1. Moisture sorption isotherms of corn at three ambient relative humidities (60%, 65%, and 70%). Source: Adapted from McNeill, 2016.

Table 1. Maximum safe storage time for shelled corn at different moisture contents and temperatures.

Moisture Content (%)	20°C (68°F)	25°C (77°F)	30°C (86°F)	35°C (95°F)
13	150 days	84 days	50 days	30 days
14	100 days	65 days	35 days	21 days
15	75 days	40 days	25 days	15 days
16	50 days	30 days	18 days	10 days
Source: MWPS-13, 2017.				

The combination of corn temperature and moisture content determines the maximum storage life of shelled corn. Research over the years has developed values and recommendations for the maximum recommended storage time for clean, aerated shelled corn stored at different temperatures and moisture contents. Table 1 summarizes these values based on MWPS-13 guidelines.

Research Overview – What was done

Stored grain conditions were monitored using ACE AIR Analyzer sensor modules (Model AZR-REG-001, Amber Agriculture, Chicago, IL, USA), equipped with CO_2, temperature, and relative humidity (RH) sensors. Six modules were deployed—three at two feed mills and four at three feedlots—suspended in the silo headspace above the grain (Fig. 2). Sensors recorded hourly measurements of CO_2, temperature (°C), and RH (%) throughout the storage period. In addition, the system logged local weather data (ambient temperature, RH, EMC, and precipitation) from nearby stations, enabling real-time monitoring of environmental factors and early detection of spoilage risk during grain drawdown.

Figure 2. Monitoring stored grain using ACE AIR Analyzer sensor modules.

By analyzing ambient weather data alongside headspace temperature and RH in some silos at two commercial storage sites, Mérida and Veracruz, seasonal aeration windows were identified to indicate optimal periods for ambient aeration to maintain corn in safe storage conditions.

Three key criteria were used to examine the data for aeration availability: average hourly ambient temperature for RH below 70%, total monthly hours meeting the RH threshold, and percentage of monthly aeration availability.

Key Findings

Headspace CO_2, temperature, and relative humidity (RH) offer strong indicators of the storage environment and the grain's risk of spoilage (Fig. 3).

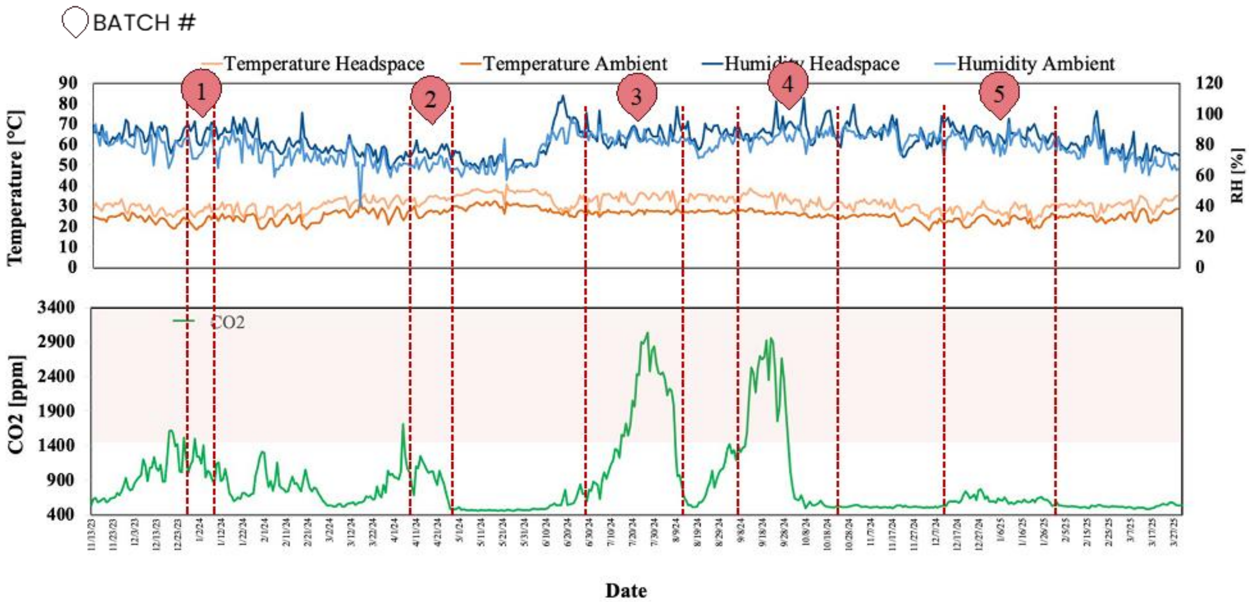

Figure 3. Trends of temperature, relative humidity, and CO_2 concentration in the headspace of a silo in a feed mill during the period of storage drawdowns (2023–2025).

Headspace temperature, ambient temperature, headspace relative humidity, ambient relative humidity, and headspace carbon dioxide (CO_2) concentration were monitored in a silo at a feed mill during the storage periods from June 22nd, 2023, to April 1st, 2025. Vertical lines (red dashed) indicate the exact dates the first and last samples were taken within a batch. The graph shows several storage batches over the study period based on grain drawdown events. CO_2 levels above 1,500 ppm, highlighted by the pink shaded area, are associated with active microbial respiration or fungal growth (Ileleji et al., 2006).

Table 2 shows the total monthly hours when RH fell below 70%. The best aeration windows occurred from April to July, each providing 350+ hours suitable for safe aeration (50% or more of the available aeration hours per month). In contrast, September and November—the most humid months—offered fewer than 200 hours, greatly limiting aeration opportunities.

Table 2. Total monthly hours with RH below 70% in Mérida.

MONTH	HOURS PER MONTH	HOURS AVAILABLE TO AERATE	% OF POTENTIAL AERATION AVAILABILITY
January	744	232	31%
February	672	296	44%
March	744	341	46%
April	720	361	50%
May	744	383	51%
June	720	362	50%
July	744	400	54%
August	744	288	39%
September	720	187	26%
October	744	206	28%
November	720	192	27%
December	744	241	32%
	8760	**3489**	**40%**

Table 3 shows the overall monthly hours with RH below 70% in Veracruz. Peak aeration windows were mostly between February and June, while the total monthly favorable hours ranged from 258 to 361 hours. However, the number of hours with RH less than 70% dropped dramatically at the beginning of July and fell to less than 140 hours in October.

Table 3. Total monthly hours with RH below 70% in Veracruz.

MONTH	HOURS PER MONTH	HOURS AVAILABLE TO AERATE	% OF POTENTIAL AERATION AVAILABILITY
January	744	201	27%
February	672	266	40%
March	744	258	35%
April	720	304	42%
May	744	361	49%
June	720	308	43%
July	744	215	29%
August	744	185	25%
September	720	164	23%
October	744	137	18%
November	720	214	30%
December	744	175	24%
	8,760	**2,098**	**32%**

Recommendations for aeration in warm, humid tropical climates

- Aeration in humid tropical climates is feasible, but it must be guided by automatic monitoring of silo conditions for real-time temperature and relative humidity.
- Short aeration windows (typically 2–4 hours when ambient RH falls below 70% and temperature below 30° C), combined with routine headspace ventilation, can substantially lower the equilibrium relative humidity inside the bin.
- Automated monitoring systems—such as AmberAg headspace sensors that track temperature, RH and CO_2—are essential for effective, automated grain aeration and headspace ventilation control.

- Use powered exhaust fans (Fig. 4) to actively ventilate the headspace above the grain, triggered by headspace relative humidity and dewpoint temperature (the temperature at which air becomes saturated and moisture begins to condense).

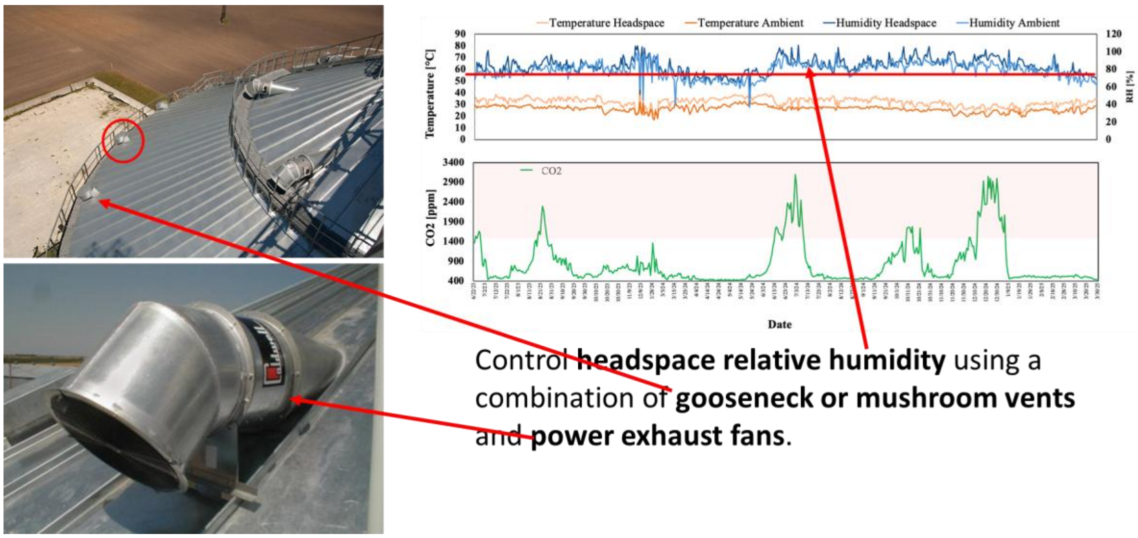

Figure 4. Use of power exhaust fans for controlling headspace relative humidity.

Best practices for managing imported U.S. corn in the humid tropics include:

- **BCFM Management:** Immediate screening and diverting BCFM for immediate use. Reduce BCFM accumulation by cleaning grain before storage or managing the core during filling to minimize economic losses.
- **Sanitation:** Prioritize thorough cleaning of discharge pits, silo surroundings, and removal of residual grain to reduce insect pressure and hotspots.
- **Aeration Techniques:** Continuous monitoring of temperature, humidity, and storage time. Apply aeration when the RH is below 70% and the temperature is <30°C. Use CO_2 and other sensors to determine real-time need.
- **Proactive Quality Checks:** Monitor CO_2 levels, temperature gradients, and aflatoxin trends to identify early signs of spoilage.
- **Staff Training:** Train facility staff on interpreting sensor data, identifying safe aeration windows, and applying good grain handling practices.

Overall, these results reinforce the importance of proper grain management in tropical climates and demonstrate a holistic approach to managing BCFM in order to maintain the quality and value of U.S. corn exports to Mexico and similar markets.

Conclusions

Despite the challenging environment for grain storage, this study shows that imported U.S. corn can be effectively managed in warm, humid tropical climates. Effective aeration in humid tropical climates requires managing moisture rather than temperature alone. High headspace relative humidity coupled with high temperatures are the primary drivers of grain deterioration, as confirmed by elevated CO_2 levels and biological activity observed in the monitored silos. The study emphasizes real-time monitoring of headspace temperature, RH, and CO_2 to guide aeration decisions. Seasonal variations dictate the timing and duration of aeration, with short micro-windows of 2–4 hours still being beneficial to reduce moisture migration, high relative humidity levels/moisture condensation in the headspace and CO_2 accumulation. Additionally, BCFM management, sanitation, and recurrent staff training should be part of a comprehensive stored grain management strategy.

References

Gomez Arauz, A.F. 2025. Factors impacting U.S. imported corn quality in tropical climates – A case study of Mexico. M.S. Thesis (unpublished, May 2025), Agricultural and Biological Engineering, Purdue University, West Lafayette, Indiana.

Ileleji, K.E., D.E. Maier, C. Bhat, and C.P. Woloshuk. 2006. Detection of a developing hot spot in stored corn with a CO_2 sensor. *Applied Engineering in Agriculture* 22(2): 275-289.

Ileleji, K.E., Gomez, A.F., and Kadota, P. 2025. Maintaining the quality and value of imported U.S. corn under tropical conditions. Final report prepared for the U.S. Grains and Bioproducts Council Report (unpublished July 2025), Mexico Storage Program, Agreement No. 19067994 between USGC and Purdue University, West Lafayette, Indiana.

MWPS-13. 2017. Grain Drying, Handling, and Storage Handbook. Midwest Plan Service, Iowa State University.

Authorship, declaration of competing interest and funding

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