Extension FactSheet
AEX-202-06
THE OHIO STATE UNIVERSITY EXTENSION
Food, Agricultural and Biological Engineering, 590 Woody Hayes Drive, Columbus, Ohio 43210

Natural Air Grain Drying in Ohio

R. C. Hansen
H. M. Keener
R. J. Gustafson

Finding ways to conserve energy and reduce costs associated with growing crops continues to be a critical challenge for Ohio agriculture. Significant energy inputs must be supplied by the farmer to grow a crop. For example, the production of an average field of corn can require an estimated 8 million Btu of purchased energy per acre. An estimated 3 million of the fuel and electrical energy use may be required for conventional grain drying.

According to survey results reported in 1996, nearly 80 percent of the shelled corn harvested in Ohio was dried on the farm. Twenty percent was dried commercially. Although natural air drying was only used by approximately 8 percent of the farmers who dried corn, it shows promise for both reduced energy input and improved grain quality when properly applied and managed.

Defining Natural Air Drying

Natural air drying is an in-bin drying system with the following typical characteristics:

- Drying process is slow, generally requiring 4 to 8 weeks.
- Initial moisture content is normally limited to 22 to 24%.
- Drying results from forcing unheated air through grain at airflow rates of 1 to 2 cfm/bu.
- Drying and storage occur in the same bin, minimizing grain handling.
- Bin is equipped with a full perforated floor, one or more high-capacity fans, a grain distributor, and stairs (see Figure 1).
- Cleaning equipment is used to remove broken kernels and fines.

Energy Can Be Saved

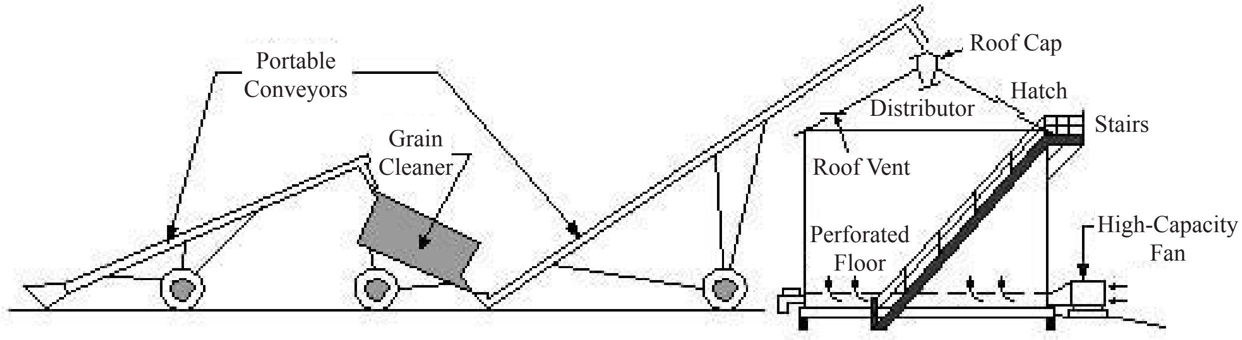
Natural air drying systems can dramatically reduce energy inputs for drying. For example, drying corn from 25.5 to 15.5% M. C. with a natural air system may use as little as 25 to 40% of the total energy of high temperature systems. Natural air drying replaces the fuel energy, usually propane, by using the natural drying potential of air over a longer period of time. However, more electrical energy is used to move the air through the bin. Total energy cost will depend on fuel and electric energy costs but it is significantly lower for natural air systems.

In addition to energy savings, well-managed natural air systems can produce a superior quality product for feeding or market. Dry, high-quality grain is the objective of any drying and storage system. Grain that is overdried not only results in excessive drying costs, but also leads to poor quality and loss in market value. Characteristics of poor quality are stress cracks, broken kernels, and fines. Overdried grain is less palatable to livestock. Grain that is underdried leads to mold and associated weight losses due to respiration. Farmers can identify very quickly with costs of poor quality when they experience price discounts in the marketplace.

Airflow Is the Key

The key to natural air drying is airflow. Rate of airflow is measured in cubic feet per minute per bushel of grain (cfm/bu). A typical airflow rate is 1.25 cfm/bu. Since the volume of one bushel is 1.25 cubic feet, an airflow rate of 1.25 cfm/bu would imply a complete air change for each bushel of grain every 0.5 minute if the pore space is 50%. Since drying rate is proportional to airflow rate, if the airflow rate is doubled, the grain drying rate doubles.

Figure 1. Recommended equipment for natural air grain drying.



Successful natural air drying requires enough air be provided to complete drying before unacceptable levels of deterioration occur (0.5% is the usual criterion for maximum allowable deterioration due to dry matter loss).

Table 1. Recommended airflow rates for natural air grain drying.

Grain Type	Initial Moisture Content (%)	Recommended Airflow Rate (cfm/bu)
Shelled Corn	20–22	1.0
	22–24	1.0–2.0
	24–26	2.0–3.0
Soybeans	16–18	1.0
	18–20	1.0–2.0
	20–22	2.0–3.0
Wheat	14–16	1.0
	16–18	1.0–2.0
	19–20	2.0–3.0

Upward airflow is recommended. With upward airflow, the grain at the top of the bin is most critical since it is last to dry. Upward airflow allows the most critical grain to be visually checked by the operator. Airflow must be sufficient to move the drying front (boundary between dry grain and grain that is not yet dry) to the top of the grain before spoilage occurs.

Generally, corn harvesting for natural air drying should be delayed until October 15 in Ohio for two reasons: 1) to take advantage of the free natural air drying that occurs in the field, and 2) to reduce the probability of the occurrence of 60 degree F days after the corn is harvested, stored, and not yet dry. As air temperature increases, the time available for drying decreases faster than the drying capacity of the air increases. The only alternative is to increase airflow rates.

Airflow rates for natural air drying are primarily controlled by fan size, grain type, bin diameter, and grain depth. Practical ranges for fan size and energy requirements limit the airflow rate and also vary according to initial moisture content. Table 1 gives a summary of recommended airflow rates for natural air grain drying.

System Selection Factors

A number of factors must be considered when selecting or operating a natural air system.

Grain Type

Because of differences in kernel size and shape, grains differ in their resistance to airflow represented as static pressure. Static pressure is the force per unit area required to overcome the resistance to airflow through the grain. Static pressure can be measured with a manometer and is usually expressed in inches of water. Static pressure requirements for soybeans are less and the requirements for wheat are more than for shelled corn. Static pressure requirements also increase as grain settles during storage and wherever fines, foreign material, and/or broken kernels fill pore spaces.

Initial Moisture Content

Recommended airflow rates for natural air drying are primarily determined by the moisture content at the time drying is started. Higher initial moisture content requires higher airflow rates. For example, Table 1 indicates airflow requirements for shelled corn triple when the initial moisture content is 26% compared to 22%. Impact is similar for the other grains. Initial moisture content has a far greater impact on the design and success of natural air drying systems than any other factor.

Climatic Conditions

Success with natural air drying has occurred in all corn and soybean growing counties in Ohio with the exception of Ashtabula and Trumbull counties (the snow belt area) in the northeastern corner of the state. For shelled corn, best results occur when the climatic conditions provide temperatures in the range of 30 to 50 degrees F and relative humidities in the range of 60 to 70%. In most western Ohio counties, October and November provide high probabilities for good climatic conditions for natural air drying of soybeans and shelled corn. Installation of an automated grain temperature/grain moisture controller significantly increases the probability of success anywhere in the state.

Bin Diameter and Grain Depth

For trouble-free, natural air shelled corn and soybean drying, a grain depth of 12 to 16 feet is preferred, while 18 to 20 feet should be a maximum grain depth. Ideal bin diameters for natural air drying are 24, 27, and 30 ft. At 18 ft of grain depth, these bins provide 6,500, 8,250, and 10,200 bu of storage capacity, respectively. For bin diameters larger than 30 ft, fan size and power requirements are often prohibitive. In addition, mechanical spreading and hand leveling become unreasonably difficult.

Since standard grain bins are built using corrugated sheets with an effective depth of 32 inches, 9 rings of sheets is an ideal maximum height because it provides a half-ring for the air plenum, 7-1/2 rings for grain storage (20 ft deep), and one ring for easy access to the top of the grain for inspection and hand leveling. Unless the initial moisture content of the shelled corn is 20% or less, the temptation to fill the 9-ring bin to the eaves during single-fill drying should be avoided.

Fan Selection

Fan size (in terms of horsepower) is based on grain type, bin diameter, grain depth, bin capacity in bushels, and desired airflow rate. Airflow requirements can be met with one, two, or more fans on the same bin. Advantages and disadvantages of vane axial versus centrifugal fans need to be compared. Fan performance varies from one manufacturer to another. Working with a qualified dealer is required to make appropriate decisions.

Electric Service Requirements

Available electric service type and capacity may represent a design constraint. High capacity fans of 20 Hp or larger, or multiple fans per bin may be required. The farmer needs to work with sales representatives for bins and fans, and the electric power supplier to make appropriate choices.

Management Suggestions for Operation of Natural Air Systems

Good management is critical to the successful operation of natural air drying systems. The following listing can be used as a guide for management of such systems in Ohio.

- Grain should be free of excess dirt, fines, and chaff. Cleaning devices are recommended.
- Keep grain level as bin is filled. Grain leveling devices are recommended.
- Start fan as soon as the bin floor is covered with grain and operate continuously until the grain is dry or the average air temperature is below 35 degrees F for extended periods.
- Leave all roof hatches open to provide a large air exhaust opening, approximately 1 sq ft for each 1,000 CFM of air delivered to the bin.
- Circular stairs should be included as standard equipment to facilitate safe and frequent grain inspection.
- Attach a manometer to the air plenum to measure static pressure and use manufacturer's fan performance charts to determine airflow.
- When the daily average temperature drops below 35 degrees F, cool the grain to a uniform temperature and turn the fan off (below 35 degrees F drying is slow and inefficient). If moldy odors are detected or the grain starts to heat, turn the fan on until the conditions are corrected. Continue the drying process when the average temperature returns to 35 degrees F or above.
- After drying is completed, close the roof hatches and cover fan inlets to prevent migrating air from adding moisture to the grain.
- Do not exceed design criteria. When necessary, limit grain depth to obtain proper airflow in relation to grain moisture content.
- Consider purchase of an automated grain temperature/grain moisture controller.
- Follow safety rules at all times while working in or around grain bins and drying equipment.

Think Safety

Warning: Flowing Grain Is Dangerous

Never enter a grain bin or other grain storage area while the grain is flowing. Flowing grain will exert forces against the body great enough to pull the average size person under the grain in only a few seconds, leading to death by suffocation.

Caution: Look Up and Live

Contact of grain augers and elevators with overhead electrical lines is a leading cause of farmstead fatalities. Always lower auger to a safe level before moving.

References

For persons interested in more detail on the selection and operation of natural air grain drying systems in Ohio, see reference #1. Bulletin 805 can be obtained by contacting the Department of Food, Agricultural and Biological Engineering, 1680 Madison Ave, Wooster, OH 44691. Other references are given for those seeking further information in this and related areas.

Hansen, R. C., H. M. Keener, and R. J. Gustafson. 1990. *Natural air grain drying: Guidelines for Ohio*. Ohio State University Extension, Bulletin 805, Agdex 110/62, The Ohio State University, Columbus, Ohio 43210.

Midwest Plan Service. 1987. *Grain drying, handling and storage handbook*. Iowa State University, Ames, Iowa 50011.

Midwest Plan Service. 1980. *Low temperature and solar grain drying handbook*. Iowa State University, Ames, Iowa 50011.

Midwest Plan Service. 1980. *Managing dry grain in storage*. AED 20, Iowa State University, Ames, Iowa 50011.

Mckenzie, B. A., and G. H. Foster. 1980. *Fan sizing and application for bin drying/cooling of grain*. Cooperative Extension Service, Purdue University, West Lafayette, IN 47907.

Hansen, R. C., M. A. Berry, H. M. Keener, and R. J. Gustafson. 1996. Current grain drying practices in Ohio. *Applied Engineering in Agriculture* 12(1): 65–69.