

Corn Harvesting, Handling, Drying, and Storage

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Introduction

Drying and storing corn on-farm can help producers and farm managers control elevator discounts and improve economic returns to their operation. The use of such facilities requires operators to maintain grain quality from the field to the point of sale to capture market premiums. Treatment of grain soon after harvest often determines the storability of a crop and can strongly influence its quality when delivered to the end-user—which may be several weeks, months, or even years after harvest. Thus, it behooves grain farmers to implement sound grain harvest, drying, and storage practices to maintain the reputation of the United States as a reliable supplier of good quality corn to the global market. Successful post-harvest grain processing with on-farm facilities requires a thorough understanding of the factors that influence grain quality.

On-farm drying and storage facilities let producers avoid excessive unloading times that often plague country elevators during the peak harvest season. Numerous delays throughout a harvest season can increase harvest losses for some individuals, especially if insects, disease, or weather threatens their crop during this period and unusually high stalk lodging problems develop.

Disadvantages of on-farm drying and storage are the high initial equipment costs and additional management requirements. Drying, handling, and storage equipment can easily cost several hundred thousand dollars, and the best way to protect this investment is through prudent management throughout harvest and the post-har-

vest period—from the field to the elevator or miller. Such an investment in drying and storage facilities mandates that producers and crop managers do a good job of maintaining grain quality after harvest and keeping it in good condition throughout the storage period. Otherwise, the potential profit from these enterprises may be lost.

Preparing for Harvest

All equipment that will contact corn as it moves from the field to the storage bin should be thoroughly cleaned prior to harvest to minimize mold and insect infestations and protect the purity of individual corn varieties or seed lots. This is especially true for genetically enhanced crops, which should be harvested after non-genetically altered crops to avoid possible/probable mixing. All combines, hauling vehicles, conveyors, drying equipment, and storage bins should be thoroughly cleaned before the rush of harvest begins.

Ideal corn varieties have high yield potential, high test weight, a sound disease-resistance package, and strong stalks to avoid lodging problems and rapid dry-down in the field, and they are disease and insect free at harvest. Less than ideal conditions require more management skill to avoid potential problems after harvest. Combines should be serviced and adjusted according to the owner's manual prior to harvest to assure minimal mechanical damage to corn kernels. Clean grain dryers, perform a routine maintenance check on the sensors and controls, and test fire the unit(s) prior to the beginning of harvest to avoid equipment downtime.

Spray the vegetation around storage bins with herbicide and thoroughly clean out bins prior to harvest to prevent creating a harborage for rodents and insects. Sweep down walls, ladders, ledges, and floors inside grain bins to remove old grain and fine material where insects and mold spores can lie in wait to contaminate the incoming crop. Provide dust protection masks so workers will avoid potential breathing problems when cleaning bins and equipment. After mowing and cleaning, spray a residual pesticide inside the bin to the point of runoff for additional protection from insects. Be sure to read pesticide labels carefully for any specific delays prior to filling the bin or other restrictions after application. It is always a good idea to fumigate the space under the false floor of grain bins to eradicate that area of insect populations. Don't confuse residual pesticides with fumigants, which have no carry-over effect, and keep in mind that fumigants are toxic to humans and other warm-blooded animals and therefore are Restricted Use pesticides.

Harvest Considerations

Harvest should begin when operators can optimize profits, which is influenced by the price of corn, potential yield, length of harvest period, weather, and costs for equipment, labor, and energy. Some of these variables change during the course of the harvest season so this is usually a very dynamic situation each year. Operators should have a realistic figure for each of these variables before harvest begins and should be flexible enough to compromise between any conflicting situations. For example, corn usually reaches the maximum dry

matter accumulation at a grain moisture level of 35 to 38 percent, but machine losses are usually lower when shelling corn below 25 percent moisture. Consequently, most farmers with dryers opt to begin harvest a little above 25 percent moisture with the hope of being able to finish before it dries completely in the field.

The length of the harvest period is highly dependent on the size of the operation, combine speed and capacity, efficiency of the harvesting-hauling-handling-drying-storage system, and weather. Total harvest losses generally increase with the time required to gather the crop and can occur from pre-harvest losses and machine losses. Pre-harvest losses can be caused by high winds, hail, or similar weather event, from disease or insect pressure, or from a combination of these situations. Machine losses are inevitable, so the challenge is to:

1. Know where they occur.
2. Understand how to measure them.
3. Know what to do to correct them.
4. Motivate combine operators to measure these losses and take action when they reach economic thresholds.

The income gained by reducing machine losses is achieved with very little added equipment and labor expense, so the time required to carefully adjust and operate the combine can be extremely profitable.

Where Do Combine Losses Occur?

Combine losses can occur during any of the three main areas of the machine (function in parentheses)—header loss (gathering), rotor or cylinder loss (threshing), or fan and shoe losses (cleaning). Table 1 shows typical losses from each machine area for an average and expert operator. Ear losses are intact ears that are left on the stalk or dropped from the header

after being snapped. Threshing losses are kernels that remain on the cob due to incomplete cylinder/rotary action. Loose kernels on the ground can be caused by shelling at the snapping rolls or by an overloaded cleaning mechanism. Differences between operators are largely due to combine adjustments and operation and can obviously impact profitability (4.3 bushels per acre in this case). Excess losses can often be avoided by taking a few minutes to measure them and by making the machine adjustments necessary to correct them.

How to Measure Combine Losses

Ear Losses

The first step in knowing whether combine losses are excessive is to determine the total loss behind the machine. Experienced operators can make this first check in five to 10 minutes and should do so when conditions change from field to field or within a field (different variety, planting date, or grain moisture level). Mark off a $\frac{1}{100}$ -acre area and look through the residue for whole and broken ears that are loose on the ground and those still attached to stalks. See Table 2 for the row length needed to make up $\frac{1}{100}$ -acre with different row widths and header sizes. Gather all whole and broken ears in this area and weigh them to the nearest 0.1 pound (1.6 ounces or 35 grams). Each $\frac{3}{4}$ -pound ear (or equivalent) represents a loss of one bushel per acre.

Table 1. Typical combine losses for operators with different skills.

Type of loss	Combine losses (% of yield)	
	Average	Expert
Ear loss	4.0	1.0
Threshing loss	0.7	0.3
Loose kernel loss	1.4	0.5
Total loss	6.1	1.8

If ear losses are more than 1 bushel per acre and many intact ears are found on stalks, pre-harvest loss should be measured. Check an adjacent $\frac{1}{100}$ -acre area of unharvested corn and gather and weigh all ears on the ground. Figure pre-harvest loss on the basis of a $\frac{3}{4}$ -pound ear. Subtract pre-harvest loss from header loss. If header loss exceeds 1 bushel per acre consider reducing ground speed, adjusting the header height, or snapping rolls to reduce this loss.

Kernel Losses

The first step in measuring loose kernel loss is to make a frame from wood, wire, or string that covers a 10-square-foot area (see Table 3 for frame dimensions for different row widths). Center the frame over each row behind the combine and count kernels still attached to broken cobs (threshing loss) and loose kernels lying on the ground (cleaning loss). A coffee can is handy to collect a commingled sample from all rows that can be inspected to assess kernel damage during threshing. Two kernels per square foot are equal to a bushel per acre loss, so divide each count from each row by 20 to determine threshing and cleaning losses. If the threshing and loose kernel loss is below 0.3 and 0.5 bushels per acre, respectively, you are an expert combine operator! If your losses exceed these limits, combine adjustments are advised. If separation loss exceeds 0.3 bushels per acre, adjust cylinder or rotor speed for better shelling.

Table 2. Row length (feet) for $\frac{1}{100}$ -acre area at different row widths and header sizes.

Row width (inches)	Header size			
	4 rows	6 rows	8 rows	12 rows
	<i>Row length (feet)</i>			
20	65.3	43.6	32.7	21.8
30	43.6	29.0	21.8	14.5
36	36.3	24.2	18.2	12.1

Table 3. Dimensions of a 10-square-foot area for different row widths.

Row width (inches)	20	30	36
Row length (inches)	72	48	40

If loose kernel loss is above 0.5 bushels per acre 1 final measurement is needed to determine the problem area. Stop the combine between the ends of the row and back it up about 20 feet. Now place the frame over each row in the area previously under the header and count loose kernels to determine header loss. The difference between loose kernels counted behind the combine and those counted under the header can be attributed to the cleaning mechanism (walker and shoe).

Adjustments to Improve Combine Performance

If excessive harvest losses are found, it is important to make the right machine adjustments quickly to minimize economic loss. Some problems require the adjustment of a single component, while others involve several different areas of the combine. It is usually best to make small individual changes one at a time and measure the outcome of that adjustment before more modifications are made.

A ground speed of 2.5 to 3 miles per hour usually produces good results. Position the header accurately over the rows to feed the material smoothly into the gathering chains and snapping rolls. Run snouts low enough so that the ears contact the upper third of the snapping rolls. Set snapping rolls according to stalk width and match their speed to ground speed to reduce ear loss.

Flights on gathering chains should be opposite each other and should extend about ¼ inch beyond the snapping bar. Chain speed should be set to guide stalks into the rolls without uprooting them. Snapping bars

should be spaced closer together in the front (~1¼ inch) than at the rear (~1⅜ inch) to avoid wedging. Keep trash knives sharp and set them as close to the rolls as possible to prevent wrapping the stalks and plugging the machine.

Operation of the cylinder/rotor affects corn kernel damage more than any other machine setting, so attention to this detail will yield large benefits during drying and storage. Grain moisture also influences the amount of kernel damage and may vary with different varieties, but fines generally increase at moisture levels above 25 percent. Since large variations exist among current combine models, producers should closely follow the operator’s manual for speed and clearance settings suggested for their cylinder or rotor machine. Avoid overthreshing, which increases kernel damage, produces excess fines, and consumes more power and fuel.

Economic Incentive to Reduce Harvest Losses

Many farmers are not aware of the magnitude of their harvest losses. Although they can vary widely from year to year, studies have shown them to be as high as 15 percent or more of potential yield. Perhaps the best mo-

tivation for measuring harvest losses is to consider the cost of grain left in the field. These are shown in Table 4 for various corn prices, potential yield, and harvest loss levels. Even with low corn prices, producers obviously need to keep losses below 5 percent regardless of yield. Also, corn left in a field will be a “weed” the following year and will have to be controlled, resulting in a higher cost.

Drying Considerations

Corn drying equipment consists of bin dryers, column dryers, or a combination of these two types. Each system uses different amounts of heat and airflow to achieve the desired capacity, control drying costs, and maintain grain quality. Regardless of the type used, high-moisture corn should be dried to 16 percent moisture within 24 hours and cooled to the outside air temperature within 48 hours after harvest to avoid losses due to heating, which can provide an ideal environment for mold activity and can lead to mycotoxin production. If heating is prolonged, dry matter loss and an associated loss in quality and test weight will most certainly occur. The amount of time that clean high-moisture corn can be held safely without a loss in quality varies with grain tem-

Table 4. Comparison of harvest losses at different yield levels and corn prices with drying energy costs.

Loss level (% of yield)	Value of harvest losses (\$/ac)					Drying energy cost ² (\$/ac)	
	Potential yield (bu/ac)	Harvest loss ¹ (bu/ac)	Corn prices (\$ / bu)			Moisture removed	
			\$ 2.00	\$ 2.50	\$ 3.00	5 pts.	10 pts.
2%	100	1.97	\$ 3.94	\$ 4.93	\$ 5.91	\$ 7.72	\$ 15.44
	150	2.96	\$ 5.91	\$ 7.39	\$ 8.87	\$ 11.58	\$ 23.16
	200	3.94	\$ 7.88	\$ 9.85	\$ 11.82	\$ 15.44	\$ 30.88
5%	100	4.93	\$ 9.85	\$ 12.31	\$ 14.78	\$ 7.48	\$ 14.96
	150	7.39	\$ 14.78	\$ 18.47	\$ 22.16	\$ 11.22	\$ 22.44
	200	9.85	\$ 19.70	\$ 24.63	\$ 29.55	\$ 14.96	\$ 29.92
8%	100	7.88	\$ 15.76	\$ 19.70	\$ 23.64	\$ 7.24	\$ 14.48
	150	11.82	\$ 23.64	\$ 29.55	\$ 35.46	\$ 10.86	\$ 21.72
	200	15.76	\$ 31.52	\$ 39.40	\$ 47.28	\$ 14.48	\$ 28.96

¹ Harvest loss above an assumed minimum of 1.5% of potential yield.

² Drying energy cost based on a fuel price of \$ 0.75 per gallon of LP or equivalent.

perature, as shown in Table 5. These times can be reduced by as much as one-half or more for broken corn with a high level of fines, trash, and foreign material.

The amount of water in shelled corn at various moisture levels is shown in Table 6. No. 2 yellow corn is usually marketed at 15.0 or 15.5 percent wet basis (w.b.), whereas food-grade corn is usually sold at 14.0 percent w.b. All corn should be dried to 13.0 percent moisture if it will be held into the summer, so the storage costs for drying and moisture shrink must be recovered by market increases. Otherwise, corn should be dried to the market level, cooled as soon as possible in the fall, and sold before warm weather the following spring rather than risk the chance of spoilage because of mold and insect activity.

Corn dryers range in capacity from a few hundred to several thousand bushels per day. Producers should size their dryer(s) to match daily combine capacity and harvest moisture target levels. Suggested operating conditions for different corn drying systems in Kentucky are listed in Table 7. More information for each drying system is available in other Extension publications.

Because fan capacity diminishes as a bin is filled, full bin drying with unheated or low temperature air takes several weeks to accomplish because of low airflow rates. Consequently, these slow processes are not recommended for corn above 18 percent moisture. Also, the top layer of corn is the last to dry in bins without stirring augers, so this layer should be checked frequently during drying to avoid environmental conditions that favor mold growth. If more drying capacity is needed, first reduce the depth of corn to increase airflow, then add more heat if possible. Other suggestions for increasing bin drying capacity are presented in the Extension publications listed in Table 7. Con-

Table 5. Allowable holding time for clean shelled corn at different temperature and moisture levels before a loss in grade occurs.¹

Grain temperature	Corn moisture content (% wet basis)						
	18%	20%	22%	24%	26%	28%	30%
	<i>Allowable holding time (days)</i>						
40° F	195	85	54	38	28	24	20
50° F	102	46	28	19	16	13	11
60° F	63	26	16	10	8	6	5
70° F	37	13	8	5	4	3	2
80° F	27	10	6	4	3	2	1

¹ A grade loss occurs when corn loses 0.5 pound of dry matter per bushel. Source: ASAE.

Table 6. Amount of water in shelled corn (test weight of 56 lb/bu) at different base moisture levels.

Moisture content, % wet basis	13	15	17	19	21	23	25	27	29
Water (15.0% base), lb/bu	7.1	8.4	9.8	11.2	12.7	14.2	15.9	17.6	19.4
Water (14.0% base), lb/bu	7.2	8.5	9.9	11.3	12.8	14.4	16.1	17.8	19.7

sider installing grain temperature and moisture content sensors in new or existing bin dryers to control fan and heater operation or unloading equipment cycles. Reducing labor and overdried or underdried corn can often quickly pay for automated controls.

High temperature in-bin and column dryers provide the most capacity and flexibility for drying corn at high moisture levels. Drying times are usually between a half-hour and two hours. A potential trouble area with these systems is the wet holding bin where grain accumulates as it is delivered from the field and awaits transfer to the dryer. When high-moisture corn stays in a wet bin too long, mold growth can begin within 24 hours and accelerate rapidly if left in the bin.

Aeration in wet holding bins provides some temperature control for wet corn, but it is not a substitute for timely drying. Hopper bottom bins are preferred for holding wet corn because they are self cleaning when unloaded completely. Consequently, it is a good idea to empty hopper tanks completely each day during harvest to avoid the possible accumulation of small amounts of wet grain. If flat bottom bins are used to hold wet corn, use a power sweep auger to unload the bin

completely each day or form a “false” hopper bottom with dry corn to facilitate daily unloading of wet grain.

Dryeration or in-bin cooling of hot, dry corn is a popular way to increase drying capacity, reduce drying costs, and reduce stress-cracked kernels, yet it can create some problems if corn is not cooled within 48 hours after drying. A minimum airflow rate of 0.5 cubic feet per minute (cfm) should be provided for each bushel of hot corn to achieve the desired cooling time. Also provide 1 square foot of roof exhaust for every 1,000 cfm of fan capacity. When cooling hot corn in a bin, the fan should run continuously to remove condensed moisture that accumulates on the roof and inside wall.

Storage Considerations

The best way to protect dry stored corn from spoilage by mold and insect activity is to apply integrated pest management practices, which are based on an understanding of the ecology of grain pests. The application of a broad range of preventive practices has a cumulative effect on pest control. Examples include cleaning grain bins and the area surrounding them prior to harvest, controlling grain moisture throughout drying, cleaning dried corn prior to storage

to remove broken kernels and trash, controlling temperature throughout storage, managing the depth of grain in the bin to permit uniform airflow, and monitoring grain during storage for temperature, moisture, and mold and insect populations. By applying all these practices, a post-harvest Integrated Pest Management (IPM) strategy can be substituted for some or all of the chemicals that have traditionally been used to control pests in stored grain.

Corn with a high level of trash and fine material that has been underdried or not dried uniformly can develop problems during storage quickly even though the average moisture readings throughout the bin may be 15 percent. Thus, it is wise to check the top layer of corn in all storage bins about a week after drying and cooling to be

sure that no moisture buildup has occurred. If elevated temperatures or moisture conditions are left unchecked, mold and insect growth can flourish even in cool weather because their activity produces heat, which accelerates grain deterioration further.

Controlling the moisture content and temperature of corn throughout the storage period is the most cost-effective way to prevent spoilage problems and potential dockage from musty odors, insects, low test weight, and poor condition. Table 8 shows the recommended storage conditions for clean corn throughout the year in Kentucky. These are based on the equilibrium moisture content properties of corn and the fact that mold and insect activity is held in check when grain temperatures are below 55°F and the relative humidity in the air space

between corn kernels is below 65 percent (Table 9 and Figure 1). Clean corn that is dried to 15 percent moisture, cooled in September to 65°F, and cooled an additional 10° to 15°F each month during the fall should store well for up to six months.

Stored corn can spoil if it is dried to the recommended moisture level but not cooled thoroughly. Uneven grain temperatures can lead to moisture migration (which usually occurs in the top center of the bin), which can promote mold growth and insect activity. Aeration equalizes grain temperatures throughout the bin and prevents moisture migration. The time required to aerate corn depends primarily on the size of the fan relative to the amount of grain. Approximate times for different combinations of fan horsepower and bin capacity are given

Table 7. Comparison of corn drying systems for Kentucky conditions.

Dryer type	Relative drying capacity (bu/day)	Airflow rate cfm/bu	Air temp. °F	Harvest moisture content limit % wet basis	Relative initial cost	Grain quality	Disadvantages	UK publication
Bin dryers								
No heat	Low (150)	1 2	Outside air	16% 18%	Low to medium	Excellent	Very limited capability at high moisture levels	AEN-23
Low temperature	Low (150)	1 2	Outside + 5 – 10	18% 20%	Low to medium	Excellent	Limited capability at high moisture levels	AEN-22
Layer fill	Low (150)	2 5	Outside + 20	22% 24%	Low to medium	Good	Limited capability at high moisture levels	AEN-56
Medium temperature	Medium (2,000)	8 - 12	120 – 140	28%	Low to medium	Good	Requires level grain depth, batch transfer, labor, and downtime	AEN-57
High temperature	High (6,000)	15 - 70	160 – 180	30%	Medium	Good	Metering equipment requires maintenance	AEN-63
Column dryers								
Recirculating	High (6,000)	75 - 125	180 – 220	30%	Medium	Good	High labor required to load/unload dryer	AEN-64
Automatic batch	High (8,000)	75 - 125	180 – 240	30%	High	Fair	Requires wet holding bin and support handling equipment	AEN-65
Continuous flow	High (10,000)	75 - 125	180 – 240	30%	High	Fair	Requires wet holding bin, support handling equipment, and controls	AEN-65
In-bin cooling away from dryers								
High temperature dryer with drieration	High (10,000)	10 – 125 & ½ - 1	120 – 240 & outside air	30% & 16%	Medium	Excellent	Requires extra grain handling and managing moisture condensation	AEN-23 AEN-65
High temperature dryer with in-bin cooling	High (10,000)	10 – 125 & ½ - 1	120 – 240 & outside air	30% & 16%	Medium	Good	More management for moisture condensation and cooling	AEN-22 AEN-65

Table 8. Recommended grain temperature and moisture levels during storage in Kentucky.¹

Month	Average air temperature	Target grain temperature	Target grain moisture content
September	70° F	60° – 70° F	14.0 %
October	60° F	50° – 60° F	15.0 %
November	47° F	42° – 52° F	15.0 %
Dec – Feb	37° F	32° – 42° F	15.0 %
March	47° F	42° – 52° F	14.0 %
April	55° F	50° – 60° F	13.0 %

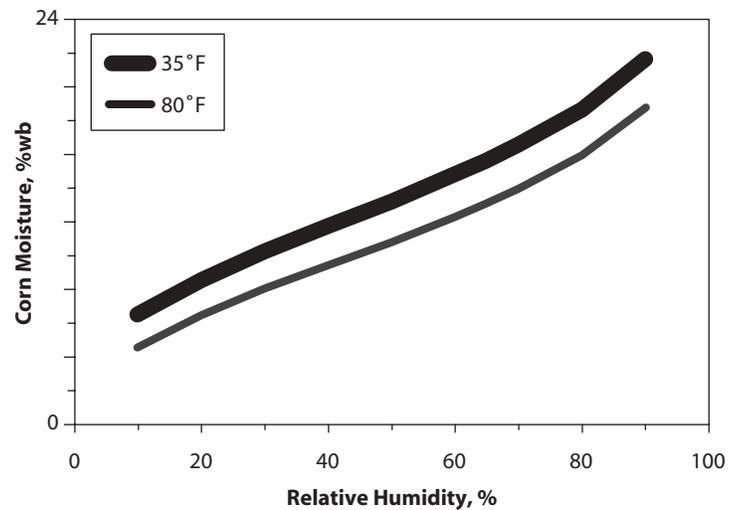
¹ Source: AEN-45, *Aeration, Inspection, and Sampling of Grain in Storage*.

in Table 10. Times shown are required to move an aeration cycle completely through a bin. Two to three cycles are normally required each fall to cool corn from 70°F to 35°F in Kentucky.

Another good management practice is to remove the top cone of corn that occupies the upper portion of the bin. Many managers are reluctant to do this because they view this as a loss of storage capacity. However, most corn storage problems in overfilled bins begin in the upper center of the grain mass because that area receives little airflow since air follows the path of least resistance and bypasses the deepest grain. While removing the top cone of corn, trash and fines that tend to accumulate in the center of the bin are reduced, which lets air move through the center of the bin much more easily. Corn from this area should be held in a separate bin and fed to livestock or sold quickly since it has a relatively high concentration of broken corn, trash, and fine material. The trade-off of removing the top cone of corn is improved airflow and adequate room for workers to probe the bin and check for possible problems.

Stored corn should be inspected every 1 to 2 weeks in the fall and spring and once every 2 to 4 weeks after conditions in the bin have stabilized during the winter months. All workers should be made aware of the suffocation and entrapment hazards that exist with flowing grain as well

Figure 1. Equilibrium moisture content (% w.b.) for shelled yellow corn for winter and summer conditions.



as the personal safety risks associated with grain dust. A safe sampling protocol is provided in more detail in Extension publication *Aeration, Inspection, and Sampling of Grain in Storage Bins* (AEN-45).

A suggested list of equipment needed to inspect stored grain safely is shown in Table 11. Corn samples

may be sealed in plastic bags and taken to a farm shop or office for observation. Kernel moisture, temperature, and condition should be recorded during each inspection and compared with previous samples. Samples should be sieved to look for insects when corn temperatures rise above 55°F. If conditions change to-

Table 9. Equilibrium moisture content (% wet basis) for shelled yellow corn.¹

Temperature		Relative humidity (%)									
°C	°F	10	20	30	40	50	60	65	70	80	90
2	35	6.5	8.6	10.3	11.8	13.3	14.8	15.7	16.6	18.7	21.7
4	40	6.2	8.3	9.9	11.5	12.9	14.5	15.3	16.2	18.3	21.3
10	50	5.7	7.8	9.4	10.9	12.3	13.8	14.7	15.5	17.6	20.5
16	60	5.3	7.3	8.9	10.3	11.8	13.3	14.1	15.0	17.0	19.9
21	70	4.9	6.9	8.4	9.9	11.3	12.8	13.6	14.4	16.4	19.4
27	80	4.6	6.5	8.0	9.4	10.8	12.3	13.1	14.0	16.0	18.8
32	90	4.2	6.1	7.7	9.1	10.5	11.9	12.7	13.5	15.5	18.4
38	100	3.9	5.8	7.3	8.7	10.1	11.5	12.3	13.1	15.1	17.9

¹ Source: ASAE Data D245.4 (average of two prediction equations).

Table 10. Approximate operating times for different size fans (by horsepower).

Fan capacity hp/1000 bu	Hours of fan operation	Operating mode when cooling hot corn ¹	Operating mode when aerating ¹
1.0	15 – 20	C	I
¾	20 – 25	C	I
½	30 – 40	C	I
¼	60 – 80	NR	C
1/5	75 – 100	NR	C
1/10	150 – 200	NR	C

¹ C = continuous fan operation for the time shown when the average air temperature is in the desired range. I = intermittent fan operation when the air temperature is in the desired range. NR = not recommended.

ward temperature or moisture levels that favor mold or insect activity (i.e., elevated grain temperature or moisture), run aeration fans to cool the corn thoroughly (see fan operating times in Table 10 as a guideline). If conditions continue to worsen, transfer the grain to another bin and collect a sample every two to five minutes during unloading. Redry moist corn to a safe level as quickly as possible or sell the lot to an elevator if drying is not an option.

Diligent monitoring of stored grain can help producers avoid problems that too often go entirely unnoticed. The authors have seen cases where grain spoilage was so severe that attempts to unload corn from a storage bin were unsuccessful because deterioration had advanced to the point where a large mass of grain was stuck together and wouldn't flow. Such cases can be avoided entirely with

Table 11. Cost estimates for tools needed to collect and inspect corn samples from on-farm bins.

Tool	Recommended/ Optional	Approximate cost
Dust mask(s)	R	\$ 1 - 500
Insect probe traps	R	\$ 20
Portable moisture meter	R	\$ 300
Dial thermometer	R	\$ 10 - 55
Grain probe/trier	R	\$ 80
Corn sieves	R	\$ 70
Temperature/RH psychrometer	R	\$ 60
Temperature readout device	O	\$ 300 - 500
Temperature cables (per bin)	O	\$ 200 - 800
Aeration controller	O	\$ 400 - 4,000
Total range		\$ 541 - 6,385

prudent management of stored corn. Hopefully, the reminders and recommended actions mentioned here will help producers and overseers of stored grain maintain and market high quality corn.