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High Moisture Grain Storage

Cooperative Extension South Dakota State University

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high moisture grain storage

Cooperative Extension Service
South Dakota State University, Brookings
U. S. Department of Agriculture
high moisture grain storage

By

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If a shortage of fuel develops for drying corn and sorghum in the fall, one way to work around the problem is to store as high moisture grain that portion of the crop to be used as livestock feed. High moisture grain storage is an efficient method of handling feed grains used by many livestock feeders as an “every-year” practice. Research and on-the-farm experiences have shown that storing high moisture grain in gas-tight storage units, reasonably tight conventional silos, and “sealed” bunker or trench silos offers farmers a low fuel-requirement alternative of storing grain in addition to several other advantages. Preserving high moisture grain with organic acid treatments in corrosion resistant bins provides another alternative for storing feed-grain successfully.

General Considerations

Advantages

Storing high moisture mature grain permits early harvest without the added expense of drying. Early harvest reduces field losses and permits greater use of corn stover as silage or grazing before snow cover.

Storage costs are usually no greater than drying and storing. If ground as it is put into storage, grain is ready to feed to livestock, eliminating the need for daily or frequent grinding. High moisture grain, stored in upright silos, can be unloaded with silo unloaders and moves easily with augers and other conveyors.

Beef gains from feeding high moisture corn or sorghum are as efficient or sometimes more so as those made on dry grain. Dairy cows produce equally well per pound of dry matter fed.

Disadvantages

High moisture grain has limited uses. It must be fed to livestock. It is difficult to market, except locally to another livestock feeder, and then the price is often discounted unless the buyer is equipped for handling high moisture grain. High moisture grain stored without acid treatment cannot be satisfactorily self-fed through conventional self-feeders. It must be fed daily to prevent spoilage or mold development. With adequate daily removal from the exposed surface, feeding high moisture grain presents little or no problems.

Storage Structure Types

Sealed gas-tight storage structures, conventional tower silos, and horizontal (bunker and trench) silos are being used successfully for storing high moisture grain. Which type to use depends on comparative annual ownership costs, expected losses, labor requirements, and managerial ability required for each storage system.

Gas-tight Storage

Sealed gas-tight units provide the most air-tight structures for storing high moisture grain. They also have the highest initial costs. The air exclusion feature allows a wider range of moisture content in the grain for safe storage. The less air allowed to get into the grain, the less will be the danger of heating and mold damage. Gas-tight units are preferred over conventional and bunker silos for whole shelled corn, although with good management high moisture grains can be stored in conventional and bunker silos.

For getting the high moisture grain out of the sealed storage unit, a mechanical unloader is installed in the bottom of the structure. For shelled corn, the auger unloader is satisfactory. For ground grain the sweep-arm bottom unloader is used to overcome the bridging problem. The gas-tight unit unloaders usually are provided with an air-tight cap which is sealed when not in use.

Conventional Silos

Conventional silos can be used for storing either high moisture ground ear corn or shelled corn (preferably ground) if they are in good condition. Spoilage losses can be held quite low with adequately reinforced silo walls that are reasonably tight, tight-fitting doors, and, after filling is completed, a plastic cap to cover the top surface of the grain to help in excluding air.

Make the conventional upright silo as air-tight as possible to help reduce losses in storage. Research has shown that with good tight silos and good management, losses may be as low as 2% to 3% of the dry matter stored. Air leakage around doors of an upright silo can be minimized by placing a plastic sheet or roll roofing between the doors and the stored grain. Some silo companies sell compounds for sealing around doors to exclude air. After filling and until feeding begins, or during any period when feeding is stopped, the top surface should be sealed with a pliable plastic sheet. This sheet should be weighted uniformly to hold it to the surface of the stored grain, especially at the edges. Silo roofs are advisable for protection against weather.

Extra reinforcement may be necessary to withstand the greater lateral pressure of high moisture grain as compared to lateral pressure from forage silage. This is especially true for older silos. Most new silos are reinforced to withstand the pressures of all types of feed that might be stored on the farm. The recommended spacing of reinforcing for concrete stave silos is shown in Table 1. Wherever possible, specific recommendations should be obtained from the company that erected the silo.

If the existing silo walls are badly pitted and in need of repair, it is usually advisable to have the work done by a silo company crew or contractor that has the equipment to do the job. Surface treatments include cement wash coats, portland cement plaster, boiled linseed oil, and various epoxy and latex materials. One treatment which has added many years of service to old concrete stave silos is the portland cement plaster coat applied to well-prepared and cleaned silo walls. Usually this can best be applied by contractors who have the equipment and specialize in this type of work. The
Table 1. Recommended Reinforcement for Silo Staves

<table>
<thead>
<tr>
<th>Distance from top (ft.)</th>
<th>Diameter of Silo (ft.)</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>5-10</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>10-15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>15-20</td>
<td>15</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>20-25</td>
<td>15</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>25-30</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>30-35</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>7 1/2</td>
<td>7 1/2</td>
<td>7 1/2</td>
</tr>
<tr>
<td>35-40</td>
<td>10</td>
<td>7 1/2</td>
<td>7 1/2</td>
<td>7 1/2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>40-45</td>
<td>10</td>
<td>7 1/2</td>
<td>7 1/2</td>
<td>7 1/2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>45-50</td>
<td>10</td>
<td>7 1/2</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>50-55</td>
<td>7 1/2</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>55-60</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

*9/16-inch round steel rods with rolled threads.
1 1/4-inch round steel rods with rolled threads.

Cement plaster is applied by trowel or shot onto the wall pneumatically. The type of treatment is best evaluated by the severity of the pitting or corrosion condition.

**Bunker and Trench Silos**

High moisture grain if properly packed and sealed will store satisfactorily in horizontal silos. It is after they are opened and exposed to air for feeding that problems may occur. For this reason planning the proper amount of open end area in relation to the rate and length of the feeding period can reduce losses during this time. Long, narrow and deep structures are suggested. Table 2 gives the pounds of high moisture ground ear corn fed at the rate of 3 inches per day for various sizes of bunker silos.

Table 2. Pounds of high moisture ground ear corn per 3-inch slice. (Based on 40 lb. per cu. ft. at 30% moisture).

<table>
<thead>
<tr>
<th>Height Feet</th>
<th>Average Silo Width in Feet</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>600</td>
<td>720</td>
<td>840</td>
<td>960</td>
<td>1080</td>
<td>1200</td>
</tr>
<tr>
<td>8</td>
<td>800</td>
<td>960</td>
<td>1120</td>
<td>1280</td>
<td>1440</td>
<td>1600</td>
</tr>
<tr>
<td>10</td>
<td>1000</td>
<td>1200</td>
<td>1400</td>
<td>1600</td>
<td>1800</td>
<td>2000</td>
</tr>
<tr>
<td>12</td>
<td>1200</td>
<td>1440</td>
<td>1680</td>
<td>1920</td>
<td>2160</td>
<td>2400</td>
</tr>
</tbody>
</table>

*Average width is calculated as follows:
Top width + Bottom width/2 = Average width
NOTE: Add 17% to these amounts if using ground shelled corn or sorghum.

The 3 inches of feeding per day is recommended in warm weather to avoid heating and mold development. The following example illustrates a method of determining the bunker or trench silo size for high moisture ground ear corn:

50 milk cows
18 pounds high moisture ground ear corn per cow per day
240 days feeding period

**STEP 1** -- Determine pounds of high moisture corn required.
50 head x 18 lb. per head per day = 900 lb/day

**STEP 2** -- Determine end area of silo required to assure feeding off at least 3 inches per day.

**STEP 3** -- Determine length.

Mechanical compaction with a tractor is commonly recommended to obtain maximum density. Sealing the walls and surface are of utmost importance to reduce losses. Six mil black polyethylene plastic sheeting, weighted down uniformly, is a popular inexpensive cover. Chopped green materials, a layer of dirt or used tires on top of the plastic holds it down to the grain quite satisfactorily. Figure 1 shows a method of sealing bunker silos.

**Management Suggestions**

When using conventional, bunker or trench silos for storing high moisture grain, the moisture content is important for fermentation and keeping qualities. High moisture shelled corn should be harvested when the kernels contain 26% to 32% moisture, and ear corn when it contains 28% to 36% moisture. Drier corn may be stored in gastight structures; however, 26% to 32% is most desirable. The amount of water to add to bring the moisture content up

Figure 1. Method used in sealing high moisture grain in bunker silos. (A) Treated Concrete Wall: Plastic sheeting is placed along side starting 2 feet from the top of wall then grain is packed against sheet, remainder of sheet folded over grain. Cover sheet is placed over both folds then weighted down with heavy material. (B) Wooden Walls are same as A except sheeting extended to floor and 2 feet under grain. Sheet must be in place before filling. (From: Montana Agricultural Experiment Station Bulletin 625 (Revised).)

**Sealing Bunker Silos**

Green Chop Manure or Dirt over Plastic (Dry Grain if indoors)

Cover Plastic Sheet
2' Fold
Plastic Sheet Side

Cover Plastic Sheet

Concrete Wall

Stored Grain

Concrete Wall

Wooden or Porous Wall

A

B
to any level can be calculated by the following formula:

\[
\text{Initial weight} \times \frac{100 - \text{init. } \% \text{ moisture}}{100 - \text{final } \% \text{ moisture}} = \text{final weight}
\]

Example: A ton (2,000 lb.) of shelled corn is at 20% moisture content and you want to bring the moisture content up to 26%. How much water must be added?

\[
A = \frac{B}{100 - C} \times (100 - D)
\]

Then, \[2162.2 \times (\text{final weight}) = 2162.2 \times 19.47 \text{ gallons.}
\]

A gallon of water weighs 8.33 lb., therefore: \[162.20 = 19.47 \text{ gallons.}
\]

High moisture grain should be ground before storing in conventional or horizontal silos. Grinding should be moderately coarse with all kernels cracked or broken. The larger pieces of cob should be no more than one-half inch in diameter to assure good packing and to prevent selection by the animal when feeding. Shelled corn and grain sorghum are usually not ground when stored in gas-tight structures as grinding tends to cause bridging which, in turn, hampers the flow of grain to auger conveyors for removal at the bottom of the silo.

The use of a distributor when filling a silo with high moisture ground ear corn is recommended to avoid the tendency of coarse pieces to roll to the outside wall as the ground corn and cob form a filling cone inside the silo. Molding is a greater possibility in the less dense areas where the larger particles accumulate.

Farmers considering the storage of high moisture grain in other than gas-tight units should plan to “balance” the amount of grain fed per day with the diameter of “exposed surface” of the silo. With whole-grain high-moisture storage, at least 3 inches per day should be removed in hot weather.

With ground grain, the amount fed per day is not as critical, especially if a surface silo unloader is used for unloading. Table 3 shows the approximate storage space in bushels of high moisture corn provided by various diameter silos.

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**Acid Treatment**

Livestock feeders might also consider preserving high moisture grain with organic acids as an alternative to ensiling or dry storage. Acid-treated grains appear to be readily digested and utilized by most animals. The primary chemicals presently used for grain preservation are the propionic and acetic acids used separately or in combination. When these acids are applied to grain, they eliminate fungi on the surface of the kernel. The acid penetrates the kernel and lowers its pH to about 4.0 to 4.5, thus inhibiting the growth of microorganisms which could cause molding, heating, and spoilage.

The germination potential of the seed is destroyed. Grain treated with acids cannot legally enter regular market channels. It can be used only for animal feed. Acid-treated high moisture grain can be stored exposed to air and in conventional or temporary emergency storage facilities, if protected from the weather.

**Acid Application**

The amount of acid to apply depends on the moisture content of the grain, type of acid, length of storage period, storage temperature and a "safety factor" to accommodate errors in moisture testing and thoroughness of mixing. *Follow the recommendations of the manufacturer* in order to get the preservation you need. Typical application rates for a preservative containing 50% propionic acid and 20% acetic acid for a one-year storage period might be expressed in percent by weight as follows:

<table>
<thead>
<tr>
<th>Grain Moisture Percent</th>
<th>% Weight of Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.60</td>
</tr>
<tr>
<td>17</td>
<td>0.70</td>
</tr>
<tr>
<td>19</td>
<td>0.85</td>
</tr>
<tr>
<td>21</td>
<td>0.95</td>
</tr>
<tr>
<td>23</td>
<td>1.10</td>
</tr>
<tr>
<td>25</td>
<td>1.20</td>
</tr>
<tr>
<td>27</td>
<td>1.33</td>
</tr>
<tr>
<td>29</td>
<td>1.45</td>
</tr>
</tbody>
</table>

Example: 2,000 lb. of shelled corn at 25% moisture. Then, 2,000 lb. x 1.20% = 24 lb. of acid per ton.

Or, the application rate may be expressed for 100% propionic acid directly in pounds per ton as follows:

<table>
<thead>
<tr>
<th>Grain Moisture Percent</th>
<th>Lb. of Acid per Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>20</td>
<td>15</td>
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<tr>
<td>22</td>
<td>17</td>
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<tr>
<td>24</td>
<td>19</td>
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<tr>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>30</td>
<td>25</td>
</tr>
</tbody>
</table>

Example: Corn at 26% moisture content. Then, 21 lb. of acid/ton (from Table) x 64 lb./bu. divided by 2,000 lb. (ton) = 0.67 lb. of acid per bushel of corn at 26%.

The usual means of application of liquid acid preservers is by specially designed applicators. (See Figure 2.) These devices use a pump, spray nozzles, a hopper, an auger, safety devices, flow meter, and a pressure gauge for flow determination. The acid is sprayed onto the grain as the auger flighting moves the grain past the nozzles. Since the acid application rate is usually a given amount of acid for a certain moisture content, the flow rate of the auger and the moisture content of the grain must be known and the acid spray volume calibrated accordingly. The acid spray hits a high percentage of kernels and further mixing occurs in the auger and when the grain drops in the bin. It is essential that no appreciable quantity of grain goes through the applicator without receiving treat-

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**Table 3. Approximate bushels per foot in silo height.**

<table>
<thead>
<tr>
<th>Moisture content %</th>
<th>Weight per bushel*</th>
<th>Cu. ft. per bushel</th>
<th>Approximate bushels per foot of silo height—silo diameter (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.5</td>
<td>56.0</td>
<td>1.25</td>
<td>123 161 203 251</td>
</tr>
<tr>
<td>24.0</td>
<td>62.5</td>
<td>1.35</td>
<td>113 148 188 232</td>
</tr>
<tr>
<td>30.0</td>
<td>67.8</td>
<td>1.44</td>
<td>117 139 176 218</td>
</tr>
</tbody>
</table>

**Shelled Corn**

<table>
<thead>
<tr>
<th>Moisture content %</th>
<th>Weight per bushel</th>
<th>Cu. ft. per bushel</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.0</td>
<td>82.8</td>
<td>2.15</td>
</tr>
<tr>
<td>28.0</td>
<td>89.2</td>
<td>2.25</td>
</tr>
<tr>
<td>30.0</td>
<td>92.1</td>
<td>2.30</td>
</tr>
<tr>
<td>32.0</td>
<td>94.6</td>
<td>2.34</td>
</tr>
<tr>
<td>26.0</td>
<td>98.0</td>
<td>2.39</td>
</tr>
</tbody>
</table>

**Ground Ear Corn**

*The weight here is the pounds of wet corn to yield one bushel of shelled corn at 15.5% moisture. (From: O. J. Berge and G. P. Barrington, "Machinery and Silo Needs for Storing Ground High Moisture Corn," University of Wisconsin.*
A pocket of untreated wet grain in a bin could cause extensive spoilage. For this reason, most applicators have a built-in safety shut-off which stops the auger if the acid flow stops.

**Storage**
Almost any facility can be used to store acid-treated grain, as long as protection from the weather is provided; bunker, conventional bins, conven-

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**Figure 2. A typical acid preservative applicator.** (From: ChemStor Liquid Grain Preservative System, Celanese Corporation.)

Applicator. The applicator is designed to treat approximately 400 to 1000 bushels per hour at 25% moisture, and is made-up of the following: 1. Hopper, 2. Auger, 3. Spray Chamber, 4. Pump, 5. Control Panel, 6. Motor.

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Procedure. The treatment of the grain starts with the unloading of the grain into the polyethylene hopper of the preservative applicator.

Next, the grain travels up the auger, at a predetermined speed. (See operating manual.)

As the grain moves up the auger, it passes through the spray chamber, where the correct amount of liquid preservative is applied automatically.

NOTE: The applicator control panel has a shutdown valve that automatically stops the unit, should the supply of preservative liquid run out.

The combination of auger speed, the tumbling action of the auger, and the thoroughness of the spray-heads, assures complete coverage of the grain to be treated. Once the grain has traveled through the applicator, it is delivered to the farmer's conveyor, and on into storage.
tional cribs, silos, and temporary plastic sheets can be used. A waterproof floor and protection from winds and precipitation are needed.

Acid and acid vapors are corrosive to steel structures. Polyethylene or polyvinyl chloride sheets are sometimes used to line metal structures to prevent corrosion. Painting the exposed metal walls and floors with anticorrosion coatings such as chlorinated rubber and coal-tar epoxy is effective on properly prepared surfaces. Check with your grain preservative supplier for recommended coating materials.

If acid-treated grain is stored in concrete structures such as silos, protective coatings are also recommended. Wood storage bins need no protection, but metal objects within the bin should be protected. Aluminum bins or parts need no protection.

Acid-treated grain can be stored without any bin or structure. The acid-treated grain may be piled on a polyethylene or polyvinyl chloride base sheet. Another sheet covers the grain pile and is mechanically sealed to the base sheet to make a plastic envelope, that forms a weather-tight casing around the grain.

Acid-treated high moisture grain stored in amounts of 1,000 bushels or more may need aeration for best results. Moisture migration and condensation could present problems as in any other stored grain, except that which is ensiled. Very low aeration rates are suggested, 1/50 to 1/25 cubic feet per minute per bushel. Higher airflow rates are not recommended and excessive aeration rates may remove some of the acid.

Treated grain may even be temporarily stored in uncovered piles on the ground, but this practice should be used as temporary emergency storage only, as precipitation will dilute the acid concentration and spoilage will occur.

**Summary**

- Propionic acid, acetic acid, mixtures of these and combinations with other acids are mild organic acids that prevent molding heating and spoilage of high moisture corn.
- Follow the application rates recommended by the manufacturer for the moisture content of the grain and length of storage.
- Have an accurate moisture test. Over-treatment of acid is safe, but undertreatment can result in spoiled grain.
- Acid treated grains appear to be readily digested and utilized by most animals.
- Propionic and acetic acids have been approved by EPA and FDA as grain preservers for grain to be used as livestock feed.
- Proper application is important. Complete coverage of all the kernels is essential.
- Store acid-treated high moisture grain in waterproof structures of corrosion-resistant materials.
- Treatment and conveying equipment should be washed thoroughly after use.
- Observe all safety measures.

No endorsements of specific products or equipment named is intended, nor is criticism implied of those not mentioned.

**Costs**

The use of acid preservatives as an alternative to drying, sealed storage, and other methods of conditioning, storing, and handling grain usually should be based on other factors as well as total cost per bushel. Factors such as convenience, ease of handling, reduced capital in structures, preference for feeding high moisture grain, and investment flexibility may make the use of acid treatments more favorable. However, cost per bushel is an important consideration. If, for example, acid sells for 29 cents per pound and the recommended rate is 0.67 lb. per bushel for 26% moisture corn to be stored for one year, the cost would be 19.4 cents per bushel for acid alone. Although the use of silos, sealed storage units, or drying systems, represents high capital investments, the total annual cost per bushel will generally run less for these than acid treatments because of the high cost of acid.

**Safety, Handling Precautions**

- Handle drums carefully and open drums slowly, allowing internal pressure to vent before removing plug completely.
- Eliminate all sources of heat and open flame from the treatment and storage area.
- Avoid breathing grain preserver vapors or spray mists. Prolonged or repeated exposure to vapors or mists warrant the use of a respirator.
- Wear protective gloves and goggles when handling acids or grain that is still wet from treating.
- When applicator or other equipment is running, keep hands and loose clothing away from moving parts.
- If skin contact occurs, immediately flush the exposed area with water for 15 minutes. A physician should be consulted in case of severe or extensive exposure. Remove the contaminated clothing immediately and wash thoroughly before rewear.
- Be aware of emergency first aid procedures in case material is accidentally swallowed or gets into the eyes. Seek prompt medical attention.
- Do not contaminate water supplies or ditches with chemical or water used for cleaning equipment.
- Do not enter storage facilities without adequate ventilation.
Other Fact Sheets in This Series

This Fact Sheet is one of six in a series dealing with fuel-energy requirements in harvesting and storage of corn and grain sorghum. The entire series includes the following:

- FS 605—Corn Harvesting Alternatives and Associated Fuel-Energy Requirements.
- FS 607—Drying the Crop with Less Fuel.
- FS 608—Efficient Corn and Sorghum Harvesting.
- FS 609—High Moisture Grain Storage
- FS 610—Temporary Storage.

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