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STORING SOYBEANS ON THE FARM

By Deane G. Carter and Leo E. Holman

The common practice of marketing two-thirds or more of the soybean crop direct from the combine tends to hold down prices, congest transportation, and overload country elevators and processors' bins. Growers who are able to hold their crop on the farm for a month or two or into the next year usually gain by doing so. The problem is that storage space on Illinois farms has lagged far behind soybean production in the state.

If you are planning to build more storage space on your farm, this circular will be helpful in solving such problems as: safe moisture limits, control of moisture, protection from insects and rodents, and type and kind of storage bins to use. The recommendations are based on nine years of cooperative research by the Illinois Agricultural Experiment Station and the U. S. Department of Agriculture.

Moisture Limits

Most storage troubles are due to high moisture. Either the soybeans are too wet when stored or moisture gets into the bins from the outside (Fig. 1).

Soybeans must be drier than corn or wheat for safe storage because they contain more oil. Research work at the Illinois Station has indicated that when soybeans are stored at 15-percent moisture or more, they go down rapidly in market grade and germination, and fat acidity goes above the market limit.

Below 15-percent moisture, farm storage is practical. How high the moisture can be depends on the season, how long the beans are stored, and whether they are for seed, market, or to be put under government loan. If moisture is between 13 and 15 percent, little

1 Deane G. Carter, Professor of Farm Structures, Department of Agricultural Engineering, University of Illinois; and Leo E. Holman, Senior Agricultural Engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture. For a detailed report on a cooperative study of storage in farm-type bins, see Illinois Bulletin 553, "A Research Report of Soybean Storage in Farm-Type Bins" (1952).
or no trouble occurs in cold weather, but spoilage starts quickly in the spring and germination drops fast. For soybeans stored under government loan, the Production and Marketing Administration requires that moisture not exceed 14 percent.

In general, 12 percent is about the dividing line between safe storage for a year or longer and danger of deterioration. At moistures lower than 12 percent, there is little danger of insect damage, and only slight moisture accumulation and crusting occurs at the surface.

Spoilage caused by leaks in a bin that was not weathertight. (Fig. 1)
STORING SOYBEANS ON THE FARM

Do not depend on guessing the moisture content of soybeans—take samples to the elevator or to the county PMA office for a test. Put each sample in a sealed pint container. Be sure each sample is average for the load or for the bin. Here is about what you can plan on for the different moistures.

**Moistures of 14 to 15 percent.** In this range you can keep soybeans through late fall and winter with little loss of quality, but serious deterioration begins when the weather warms up. Ordinarily do not use for seed.

**Moistures of 13 to 14 percent.** The market crop can be stored from fall until the following late spring or early summer. If you intend the beans for seed, make germination tests before planting. In research studies, soybeans became musty and graded “sample” after ten months’ storage from January to October. Germination decreased and fat acidity went up.

**Moistures of 12 to 13 percent.** Crop is generally safe for at least a year of storage, with little loss in germination. In tests the market grade did not go down for more than two years.

**Moistures below 12 percent.** At this relatively low moisture your beans are safe from trouble due to moisture content at time of storage. “Splits” are likely to occur from handling. Beans may pick up some moisture, and some accumulation can be expected in the upper part of the bin during the winter. Germination stays good until well into the second year. Market beans at 10-percent moisture were held for nearly four years in farm-type bins without a reduction in grade.

**Control of Moisture**

**Field conditions.** Immature frosted beans or those damaged by wet weather, lodging, or late harvest may give trouble. Otherwise the crop is usually all right for storage if you do not start combining until late in the morning and do the work in good weather.

Moisture in the standing crop varies according to the time of day. Field tests made at Ames, Iowa, and Urbana, Illinois, in mid-October indicated a range from about 15 percent at 8:30 in the morning to 11 percent in the hour before noon and 9 percent during most of the afternoon. Moistures also vary with the maturity of the beans and
Within soybean bins air moves slowly up through the center during fall and winter and down through the center during spring and summer. The winter movement results in excess moisture in the upper layers after winter storage and in molding, crusting, and loss of germination in the surface beans. (Fig. 2)

The weather during harvest. Moisture tests on 400 truck loads delivered at a local elevator in Champaign county, Illinois, between September 25 and October 16, showed that 85 percent of the deliveries were above 12-percent moisture.

Moisture accumulation in bins. Heating, insect infestation, and other damage may occur even if the average moisture in your bin is low enough for safe storage. One wet load put in or a leak in the wall or roof may start trouble. The most common problem, however, is the

A bin at Urbana was filled with soybeans averaging 12 to 13 percent moisture. After sixteen months of storage part of the surface beans averaged 24 percent because of the air movement illustrated in Fig. 2. (Fig. 3)
increase of moisture in the upper part of the bin. Surface crusting and molding may develop, and germination drops severely in the beans at the top.

The trouble becomes worse as bin moistures go above 12 percent. This is what happens: During fall and early winter the beans cool near the walls and at the top, while the center stays relatively warm (Fig. 2). This difference sets up a slow air movement downward near the outside walls and up through the center. Moisture is carried from the warm portion to the cold surface, where condensation adds to the moisture in the surface layer. As a result, it is not uncommon to find moisture above 15 percent in the upper portion of bins (Fig. 3) during the winter. Raking or stirring the surface helps some to break up a crust but does little drying.

High-moisture soybeans can be dried enough by forced air for safe storage. Drying with heated air is faster than with unheated air and depends less on weather conditions. The drier shown here utilizes heat from the gasoline engine which drives the fan.
Do not use grain from the upper 2 feet for seed. If you can see the damage, remove several bushels before emptying the entire bin to prevent lowering the grade for the whole lot. In 2,000-bushel and larger bins, a duct system and motor-driven fan will draw cold air downward to cool the grain and keep the surface in good condition.

**Drying.** You can expect little or no benefit from natural air circulation through ducts, tunnels, or roof vents. Forced-air ventilation is practical if your bin is equipped with a perforated floor or ducts so that a portable drier or a fan can be attached; or you can use a column-type batch drier, or a bin drier (Figs. 4 and 5). But unless

![Diagram of a bin with air inlets and outlets](image)

**Arrangement for forced-air drying.** While drying without heat can be done at depths up to 10 feet, it is better in farm bins to limit the depth to 6 or 8 feet. With heated air, however, a 6-foot depth means that the grain in the lower part of the bin has to be overdried to reduce the moisture at all in the upper part; 5 feet or less is a better depth. (Fig. 5)
you can also use fans or heaters and other drying equipment for such purposes as hay finishing or corn drying, it will rarely pay you to dry soybeans in the amounts raised on most farms.

Slow drying can be done with forced unheated air when the temperature is above 60° and the relative humidity is below 75 percent; but such ventilation is useless in cold damp weather. Drying with heated air can do the job regardless of weather.

It is not practical to force a large amount of air through deep layers of soybeans. Depths of 4 to 6 feet are all right for airflow rates of 5 to 10 cubic feet per minute per bushel. At rates above 10 cubic feet and with a 6-foot depth, excessive power is required because of high resistance to airflow. With heated air it is better to limit the depth of grain to 5 feet or less and increase the airflow. With unheated air grain depths of 10 feet are all right with airflow rates up to 3 cubic feet per minute per bushel.

The highest temperature currently recommended for farm drying with heated air is 140° F. For seed stock 110° is the upper limit. At depths of more than 4 to 5 feet, drying is more uniform if the air temperature is raised only 10 to 15 degrees above outdoor temperature; at higher temperatures much of the grain will be overdried. For faster drying, use thinner layers of grain, down to 1 to 2 feet, increase airflow up to 60 cubic feet per minute per bushel, and raise the temperature of the entering air toward the maximum of 140°. (See Illinois Bulletin 553 for results of drying studies.)

**Temperature Control**

If the moisture content of your soybeans is within the limits recommended, you need not be concerned about ordinary summer temperature in bins. Nothing is gained under Illinois conditions by attempting to hold temperature down through the use of a particular color, size, or shape of the bin or a particular building material. In bins holding 2,000 bushels or more, artificial cooling in the winter helps to maintain good conditions. A slow downdraft fan-cooling system can be used.

If the beans seems to be heating because of insect activity or wet spots in the bin, transfer the beans to another bin. This tends to aerate and cool the beans slightly and break up the hot spots.
Insect and Rodent Control

Insect damage was slight in the Illinois studies, and no problem was found in dry, mature soybeans stored for two years. But high moisture or warm weather may cause trouble. If so, you may have to fumigate.

Rats and mice can be kept out by using recommended construction for bins, coupled with the use of poison where rodents are particularly troublesome.

Types of Bins

Soybeans can be stored in any sort of bin or space that is completely weathertight and that has walls and floors strong enough to carry the loads. Overhead bins in double cribs are suitable if they are built to hold shelled corn. Otherwise ground-level bins are best for farm storage. Large-scale storage is most economical in warehouse-type buildings or in silo-like circular masonry or metal bins.

Farm-storage bins are usually one of two types: either circular metal or rectangular wood-frame. Besides being built of different

The walls of old or leaky bins can be improved and made weathertight by a covering of wood siding, exterior plywood, sheet metal, or other building sheets. This bin has an asphalt-type siding. (Fig. 6)
kinds of material, they also differ in the type of floors and foundations. Bins fixed in place should usually be built with concrete foundations and floors.

Circular steel or aluminum bins have the advantages of light weight, low cost, and the speed with which they can be built. They can be bought from any of several manufacturers or from local dealers. Usual sizes for farm storage range from 1,000 to about 3,000 bushels. One of the main problems is how to anchor them against wind damage when they are empty.

Rectangular wood-frame bins fit in somewhat better with the shape and style of other farm buildings. You can choose whatever material you want, use salvaged material if you wish, and do all or part of the construction work yourself. Floors may be either wood or concrete. Wood bins can be readily anchored and braced. You can, if you choose, build such a building so it can be converted to other uses if it is not needed for soybeans.

**Bin Construction**

**Foundations for wood-frame bins.** Concrete foundations and floors are recommended for permanent buildings. Use 8-by-12-inch footings, 16 inches or more in the ground. Build foundation wall to a height of 12 inches or more above grade. Either 8-by-8-by-16-inch blocks or poured concrete is satisfactory. Floor with 4 inches of concrete on a 4- to 6-inch gravel fill.

Temporary foundations for wood-floored bins are started by leveling the ground and removing grass and loose soil. Place concrete blocks with the cores horizontal, spaced according to the building plan. Lay a 2-by-6 sill over the blocks, both to help equalize the load and to keep the blocks from tipping (Fig. 7, lower).

**Foundations for metal bins.** For a permanent base, use a concrete foundation ring 8 inches wide on an 8-by-12-inch footing. Place bottom of footing 16 inches or more in the ground and the top 8 inches or more above the ground level. Extending the foundation to a height of 18 or 20 inches makes it possible to get a trench in the floor for an elevator drag. Fill inside the foundation with tamped earth and 6 inches of gravel so that the top of a 4-inch concrete floor will be an inch or two higher than the base of the metal bin.
Three types of bin foundations. Upper picture shows metal ring, asphalt-coated and extending about 18 inches into the ground. In the center is a block ring and earth fill for steel-floored bins. Lower picture shows concrete blocks used as temporary foundation for wood bin. (Fig. 7)
Either of two types of temporary bases is suitable for bins with metal floors. Make a mound of about 12 cubic yards of crushed rock, smooth up with a slight raise in the center, and level out to about two feet beyond the walls. Or build a ring of concrete blocks with the cores vertical. Make the outside of the ring only 2 or 3 inches more than the diameter of the bin. Fill inside with tamped earth mounded slightly higher than the block ring (Fig. 7, center).

A metal foundation ring has recently been made available as a part of new circular metal bins. It replaces other types of foundations. The ring helps to make bins weathertight because the foundation and wall sections are bolted together. To install, excavate a trench 6 inches wide and 18 inches deep. Set the ring with its metal footing in the trench, then tamp earth fill around it (Fig. 7, upper).

**Anchors.** Where the metal foundation ring is used, it provides adequate anchoring.

Steel or aluminum bins either on rock fills or block-ring foundations must be fastened down. For typical bins (holding up to 2,000 bushels), connect anchor bars to the wall at four points and wire to “dead men” placed 2 to 3 feet into the ground and 3 or 4 feet from the wall.

Sometimes bins are anchored with wood posts set at four places around the bin. To use this method, set 4-inch by 7-foot posts 3½ feet in the ground. Bolt posts to the wall and use a strand of No. 9 wire drawn tight around the outside of the posts both at the top and near the ground. Some trouble has been encountered with post anchors, particularly when used with bins above 2,000-bushel capacity, so manufacturer’s instructions for anchoring should be followed exactly.

If concrete foundations are used, anchor both wood and metal buildings with bolts embedded a foot or more into the concrete at intervals of 6 to 8 feet.

**Walls and roofs.** Construction of wood-frame bins is well standardized and detailed in building plans. Three principal precautions are needed: (1) put in crossties and braces to prevent bulging; (2) use two layers of material in sidewalls, either lining and siding or a double layer outside the studs; and (3) extend the roof several inches beyond the plate to keep rainwater from running down the wall.
These bins are typical of those commonly used for soybean storage in Illinois. Sizes may be varied according to the capacity needed. Detailed plans for these and other bins may be obtained from the University of Illinois College of Agriculture. (Fig. 8)
Plans for Storage Bins

Plans for bins and granaries that can be built on the farm have been designed on the basis of findings from research at Illinois and other places (Figs. 8 and 9). Twenty bin plans are listed in Illinois Circular 666, "Plans for Farm Buildings and Livestock Equipment." Many plans are listed in the catalog "Grain Storage Building Plans" of the Midwest Plan Service.

Write to the ILLINOIS COLLEGE OF AGRICULTURE at URBANA or see your farm adviser for a copy of Circular 666 or about ordering the Midwest catalog or obtaining working drawings.

Buying Ready-Made Bins

Circular steel and aluminum bins holding up to 3,000 bushels of soybeans are the most common manufactured types and are usually the most suitable for farm needs.

For a larger storage capacity, choose either wood or metal utility buildings with concrete floors. These bins need extra heavy sidewall construction or ample ties to prevent spreading. Masonry silos, reinforced against grain pressures, are also satisfactory.

Manufacturers constantly use the results of research to improve their bins. Their instruction books will tell you how to get a good job of erection. Follow the directions carefully to avoid trouble from leakage and wind damage.

TO MEASURE BIN CAPACITY OR SPACE NEEDED

Soybeans occupy 1 1/4 cubic feet per bushel. To find the capacity of a bin, take four-fifths of its volume; to find the cubic feet of space needed for any size of crop, take five-fourths of the number of bushels.

To get a rough measure of the cubic-foot volume of a circular bin, take three-fourths times the diameter squared, times the height (in feet). For a rectangular bin, of course, cubic-foot volume is obtained by multiplying width by length by height.
Problems connected with soybean storage were studied with these bins on the Experiment Station farm at Urbana. The recommendations made in this circular are in general based on the results of such studies. (Fig. 9)