SDSU Extension

iGrow Soybean

BEST MANAGEMENT PRACTICES

Chapter 41:
Soybean Storage, Drying, and Yield Estimates

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In many years, soybean drying is required to insure that the crop will be available to sell in the following year. Prior to storing soybean, the bin should be cleaned and potential pest problems controlled (Chapter 42). This chapter discusses soil moisture calculations, drying rules of thumb (Table 41.1), and yield estimates.

Table 41.1. Soybean drying rules of thumb.

- The equilibrium soybean moisture content is a function of air temperature and relative humidity.
- Because of the high oil content in soybeans, beans should be stored at 2-3 moisture percentage points below what is the acceptable moisture content for storing corn.
- For short-term winter storage, 12-13 percent moisture content is usually acceptable.
- In both the field and elevator, soybeans generally dry faster than corn.
- As a general rule, do not exceed a plenum temperature of 130° F for commercial beans and do not exceed a plenum temperature of 100° F for seed beans.
- It is suggest that for maximum efficiency of drying and minimum damage to the beans, a 20-degree increase in plenum temperature should be the goal when drying beans.

Figure 41.1. Grain elevator in Saskatchewan.
(Source: http://esask.uregina.ca/entry/grain_elevators.html)

Harvest moisture content

To understand soybean drying, a basic understanding of grain moisture content is needed. Soybean is sold on a wet basis using the calculations shown below.

$$\%\ \text{Grain moisture} = \left(\frac{\text{Water Weight}}{\text{Water Weight} + \text{Dry soybean weight}} \right) 100\%$$

$$\text{water weight} = \left(\frac{\frac{\%\text{moisture}}{100} \times \text{Dry soybean weight}}{1 - \%\text{moisture}/100} \right)$$

Other critical information to know about soybean moisture content is that at 13.5% moisture, a bushel of soybeans weighs 60 lbs. This 60 lbs/bushel weight consists of 52.2 lbs of dry beans and 7.8 lbs of water. Many elevators assume that a bushel of soybeans weighs 60 lbs regardless of the moisture content. This means that if you sell soybeans at 10% moisture, it's assumed that they contain 13.5% moisture. Sixty lbs of beans at 10% moisture contain more dry beans than 60 lbs of beans at 13.5% moisture. This assumption means that by letting soybeans dry to 10% moisture, it costs you money. Examples of grain moisture calculations are available in Clay et al. (2012) and Chapter 53.

As a rule of thumb, the optimum soybean harvest moisture content is between 13% and 15%. If the soybeans are drier than 11% moisture, significant shattering losses can occur. In many combines, significant crushing and damage problems can occur when the soybean moisture content exceeds 15% to 18%. Typically in South Dakota, the moisture content of soybeans will be 13% in middle to late October. However, if beans are not dry by mid October, the atmosphere's natural drying potential is greatly diminished. Harvesting wet soybeans may be the only alternative, since it is also clear that significant pre-harvest losses occur when soybeans are left in the field.

Storage

Because of the high oil content of soybeans, they should be stored at 2-3 moisture percentage points below what is the acceptable for corn (Table 41.2). For short-term winter storage, 12-13% moisture is usually acceptable. If you are planning to store soybeans over the summer, they should be dried down to 11% moisture. If there are green beans present, lower the moisture percentage an additional two points. When in storage, soybeans should be monitored weekly.

Drying

Table 41.2 shows that soybean moisture content is a function of air temperature and relative humidity. Soybeans, being round, have about 25% less airflow resistance than corn. Therefore, when placing soybeans in a drying system designed for corn, the beans will dry more rapidly than corn. For this reason, soybeans are easier to dry than corn. However, there have been years that were so humid and cold that soybeans could not dry to an acceptable level. In those years, drying may be the preferred alternative to leaving the beans in the field.

Table 41.2. The influence of relative humidity and temperature on the soybean moisture content.
(Modified from ASAE D245.4)

Relative Humidity	Soybean Equilibrium Moisture Content			
	35ºF	50ºF	65ºF	80ºF
% RH	% moisture content			
30%	6.6%	6.1%	5.6%	5.2%
45%	9.1%	8.6%	8.2%	7.8%
60%	11.7%	11.2%	10.8%	10.4%
75%	14.8%	14.4%	14.0%	13.6%

To understand soybean drying, Table 41.2 is critical. Table 41.2 shows that at an air temperature of 65°F and an air moisture content of 60% relative humidity, soybeans can dry no further than to 10.8% MC. This means that if relative humidity is >75%, it is not possible to dry the soybean to below 13% to 14% moisture. Soybeans can be dried in conventional corn drying facilities, but extreme caution must be exercised. Soybeans are more fragile than most cereal grains.

As a general rule do not exceed a plenum temperature of 130°F for commercial beans and do not exceed a plenum temperature of 100°F for seed beans.

As a crude rule of thumb, heating air 20°F will lower the relative humidity of air to ½ the initial relative humidity. It is suggest that for maximum efficiency the oven temperature should be 20 degrees higher than air temperature.

As with corn, air-only drying can be effective. If beans are put in the bin at 18% to 20% moisture content, use the suggested airflow of about 1-1.25cfm/bu (minimum 0.5 cfm/bu), (for a 20-25 ft deep bin). For this flow rate, approximately 1 hp/1000 bu is required. With natural air drying, it will typically take about 70 days to decrease the moisture content from 20% to 13%. If the air temperature falls below freezing before drying has been completed, cool the beans to about 30°F. Resume drying in the spring when the air temperature rises above 40°F. If beans are at less than 15%, 0.1 to 0.2 cfm/bu should provide sufficient airflow to finish drying.

Green beans

In some years and with some varieties of soybeans, an early frost may result in your harvest containing many immature green beans. Natural-air or low-temperature drying at a minimum of 0.5 cfm/bu can help to limit the amount of bean damage from drying. For the long exposure times, limit the heat added to 20ºF above the ambient temperature. High-temperature systems may leave higher amounts of green beans, which translates into higher dockage at the elevator. If there are significant numbers of green beans, there is some evidence to indicate that for long-term storage, the moisture should be lowered an additional two points.

Yield estimates

Yield estimates can be used to guide management and marketing decisions. For soybean yield estimates, information on the number plants/acre, the number of seeds/pod, and the number of seeds/pound are needed. As the season progresses, the number of assumptions associated with these critical values decrease, which in turn increases accuracy. An additional purpose of this chapter is to provide guidance on soybean yield estimates at three different growth stages.

Most northern soybean varieties have an indeterminate growth habit (Chapter 3). Indeterminate growth means that plants develop leaves and flowers simultaneously during the reproductive growth stages. Yields in plants with indeterminate growth are limited by season length. Early season yield estimates are based on average growing season lengths, which can vary substantially from season to season. As the season progresses, yield estimates generally improve.

Early season yield estimates

Early in the season we can develop our first yield approximation (a scientific guess) by counting the plant population and assuming the beans/plant and soybeans/bu. We recommend the 1/1000 of an acre method for estimating the plant population. You need to first measure the row spacing. You will then use Table 40.3 to determine the distance that constitutes 1/1000 of an acre. For example, the length of row for 1/1000 of an acre when the row spacing is 20 inches is 26 feet and 1.6 inches. To estimate the plant population, you count the number of plants contained in 1/1000 of an acre at 10 locations and then multiply the average population by 1000. The length of row to produce 1/1000 of an acre is directly related to the row spacing (Table 41.3).

Table 41.3. Distance as a function of row spacing that is required to constitute an area of 1/1000 of an acre.
(Data from C.G. Carlson and K. Gustafson, SDSU)

	A	B	C	D	E	F	G	H	I	J	K
3			distance as a function of row width for 1/1000 acre								
4					Row width (inches)						
5		6	7	8	10	14	15	20	21	28	30
6	feet	87	74	65	52	37	34	26	24	18	17
7	inches	1.4	8.1	4.1	3.3	4.0	10.2	1.6	10.7	8.0	5.1

For early season estimates, assume that a plant contains 60 beans and that there are 215,000 beans per bushel (60 lbs/bushel). For South Dakota, these are reasonable assumptions. It should be noted that there is much error inherent in these assumptions. If in a 20-inch row bean field we count 140 bean plants in a 26-foot and 1.6-inch row, the estimated yield is 39.1 bu/acre. This calculation is shown below:

$$\frac{140{,}000\ plants}{acre} \times \frac{60\ beans}{plant} \times \frac{1\ bushel\ beans}{215{,}000\ beans} = \frac{39.1\ bushel}{acre}$$

Later in the season estimates

During the reproductive stages, the number of pods per plant can be counted. Based on this value, yield estimates are improved. However, it is important to point out that soybean plants will continue to produce pods as the growing season progresses. Yields at this growth stage are estimated by determining the plant population and the number of pods per plant. In a particular area, select at least 10 plants to determine the average number of pods/plant. If the row spacing is 20 inches and there are 140 plants in 26-foot and 1.6-

inch of row and if there are 26 pods/plant, then the yield estimate is 42.3 bushel acre. The calculation for this estimate is below.

$$\frac{140{,}000\ plants}{acre} \times \frac{26\ pods}{plant} \times \frac{2.5\ beans}{pod} \times \frac{1\ bushel\ beans}{215{,}000\ beans} = \frac{42.3\ bushel}{acre}$$

Seed Size	Seeds/bu	Seeds/lbs	Seeds/ft²
small	350,000	5838	8.0
medium	260,000	43333	6.0
large	170,000	28333	3.9

Figure 41.2. Average soybean sizes and the conversion of the number of soybean per ft² to bu/acre. (Photo courtesy of Brent Turnipseed, SDSU Seed Lab)

Yield estimates as harvest approaches

As harvest approaches, the number of soybean per pod can be counted. For this measurement, the number of beans per pod should be counted in 10 plants. At this time, count the beans found on each plant, determine the average bean count/plant, and estimate a bean size (small, medium, or large) (Fig. 41.2).

Seed sizes can be measured with a micrometer. The number of seed per lb decrease with increasing seed size. The relationship between seed diameter and seeds per bushel is below (Table 41.4):

$$\frac{seed}{bu} = 43560 \times (0.31366 \times (\max dia\ horizontal\ axis\ inch)^{-1.9437})$$

Table 41.4. The conversion of soybean seed diameter to seeds per bushel.
(Data from C.G. Carlson and K. Gustafson, SDSU)

32nd of inch	fraction of inch	bean/ft² =bu/acre	seed/bu
6	0.1875	8.119813	353699
7	0.21875	6.017561	262125
8	0.25	4.641952	202203.4
9	0.28125	3.692111	160828.4
10	0.3125	3.008397	131045.8
11	0.34375	2.499652	108884.9

For example, 1) if the row width is 20 inches, 2) if there are 140 plants in a row length of 26 ft plus 1.6 inches, 3) if there are on average 67 beans/plant, and 4) if the bean size is medium to large (237,000 beans/bu), then the yield estimate is 39.6 bushels/acre.

References and additional information

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