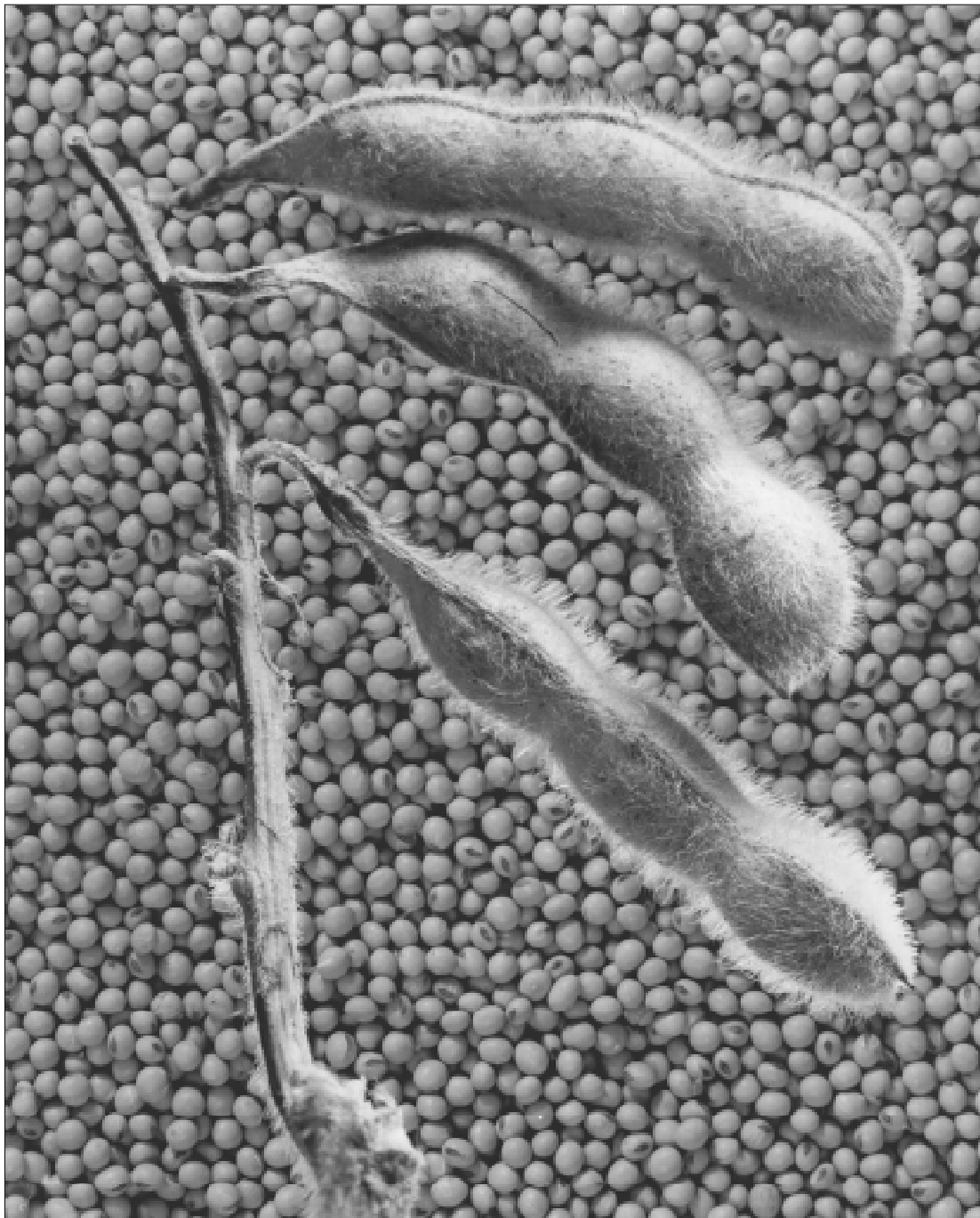




Soybean Production in Kentucky

Part V: Harvesting, Drying, Storage, and Marketing



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Part five of a five-part series

Harvesting

The harvesting operation is as important as any other soybean production practice. Unnecessary losses can change a potential profit to a loss. It is not sound management to do a good job of producing soybeans up to harvest and then leave a significant percent of your crop in the field because of poor harvesting techniques.

Surveys indicate that harvest losses average about 10%, and can range as high as 20% or more and as low as 1-2%. Although harvesting losses cannot be reduced to zero, proper combine adjustment and operation can reduce losses to an acceptable level. Harvest losses of 5% or less are considered acceptable and if your losses do not exceed 3% you are doing an expert job of harvesting. Your ultimate goal should be to keep total harvest losses below 1½ bu/acre.

The time spent on proper combine adjustment and operation can be valuable.

Example: A 40 bu/acre yield and 15% harvest loss results in a loss of 6 bu/acre. If you reduce these losses to 5%, you gain 4 bu/acre. In turn this would result in a return of \$24/acre (at a price of \$6/bu) for time spent in proper combine adjustment and operation.

Types of Harvesting Losses

The losses that occur in soybean harvesting can be divided into three major categories (see Figure 1).

1) Preharvest losses. Seed or pods detached from the stalk and lying on the ground prior to harvesting. These losses are due to natural causes, mainly shattering and broken stalks, and are not related to the combine. In most instances, these losses are low if soybeans are harvested on time. Lodged soybeans could be included as part of these losses. However, since some of the lodged soybeans could be harvested, any

lodging losses are best included under gathering losses.

2) Gathering (header) losses. Losses from seeds not gathered into the combine, including all losses occurring at the header caused by actions of the cutterbar, reel, and auger as well as losses from seeds left on the stubble. These losses often account for more than 80% of the total loss at harvest. Gathering losses can be further divided as follows:

a) Shatter losses. Shelled seeds and detached pods that are shattered from stalks by the header and fall to the ground without going through the combine. These losses usually account for almost 50% of the gathering loss.

b) Stubble losses. Seeds remaining in pods attached to stubble, caused by operating the cutter bar too high. This category includes seed remaining in pods attached to lodged stalks that were not cut or, if cut, were cut at lengths greater than the average stubble height.

c) Loose stalk losses. Seeds remaining in pods attached to stalks that were cut but not delivered into the combine.

3) Threshing and cleaning losses result from those operations within the combine. For well adjusted combines these losses are normally small.

a) Threshing (cylinder) losses. Unthreshed seeds remaining in pods that pass through the combine and also losses due to seeds cracked by the cylinder.

b) Cleaning (rack and sieve) losses. Shelled seeds that are carried out the back of the machine.

Measuring Soybean Losses

Effective combine adjustments can be made only if the amount and source of the harvest losses are known. The most practical way to measure losses is to stop the combine periodically in the field and count the number of soybean seeds lost per unit area. On the average, 4 seeds/sq ft left in the field represents a one bu/acre loss.

To measure losses, construct a rectangular frame which encloses an area of 10 sq ft (or 20 sq ft) and is **equal in length** to the combine header size (see Table 1).

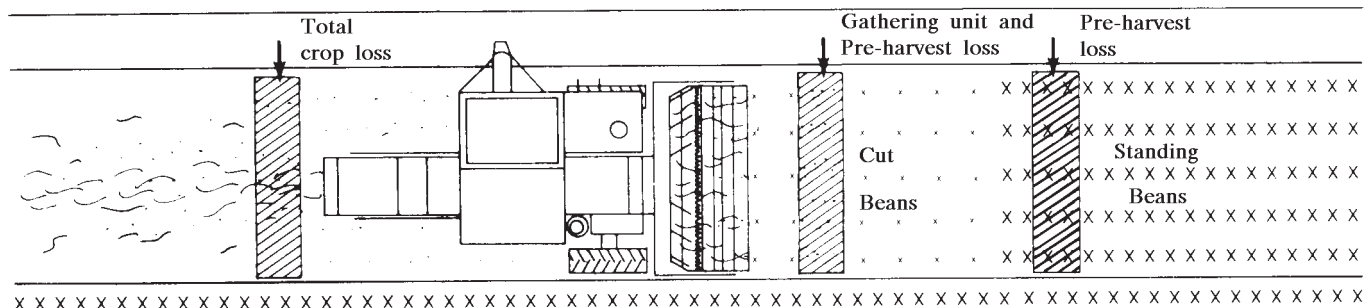


Figure 1. The shaded areas in the figure above indicate where measurements should be taken for the various harvest losses.

Example: If the combine head is 16 ft in length, then the rectangular frame should be 16 ft in length and 7½ inches in width to equal an area of 10 sq ft. This measuring frame can be made with heavy string and four stakes or wire pins tied to it to mark the corners. Make counts of loose seeds and seed in pods within the frame and divide the counts in 10 sq ft by 40 (or the counts in 20 sq ft by 80) to determine the loss in bu/acre.

Table 1. Dimensions for Rectangular Frame for a 10 sq ft Area Based on a Frame Length Equal to the Combine Header Size.

Header Size (ft)	Frame Width (in.)*
8	15
10	12
12	10
13	9¼
14	8
16	7½
18	6
20	6
22	5½
24	5

*For a 20 sq ft area, double the frame width.

Pre-harvest losses are determined by counting seeds on the ground in standing soybeans not yet harvested. Since pre-harvest lodging loss is difficult to estimate prior to harvest, it is best measured as part of the gathering loss.

Gathering (or header) losses can be made by stopping the forward movement of the combine, backing up the combine a few feet, and then making the counts in an area that only the header has covered. Count all seeds in the frame and subtract the pre-harvest loss count. When making the gathering (header) loss counts, you can pinpoint the source of the loss by keeping the counts separate for shatter loss, stubble loss, and loose stalk loss.

Total harvest loss can be measured by counting all seeds in an area behind the combine that has been harvested.

Threshing and cleaning losses can be determined by subtracting the total gathering unit and pre-harvest loss counts from the total harvest loss count. *Table 2* contains a worksheet to record and calculate your harvest losses.

When to Harvest

It is important to complete the harvest as soon as possible once the soybeans are ready, because harvesting losses increase rapidly as soybeans dry out. The period when soybeans can be harvested with minimum loss may be only a few days since moisture content can change rapidly.

The acceptable range for harvesting soybeans can be from 11-20% moisture content; 13-15% is desirable. A good rule is to start as soon as the moisture content reaches 14-16% and continue until the field is harvested. Seed damage and combine shattering losses increase as moisture content decreases.

Harvest promptly if moisture reaches 13% and finish before moisture drops to 11%. Below this level, shatter losses and seed damage losses increase substantially. It is best to start early enough so that the moisture content is not below 13% before harvest is completed.

Producers with on-farm drying and storage have an additional advantage: they can increase the upper limit on harvest moisture content to 16% or above. However, it is not recommended to start any higher than 18% moisture content. **Advantages of high moisture harvest** are earlier harvest, less shatter loss, and more available harvesting time. **Disadvantages** include more threshing loss, more damaged seed (bruising and seedcoat damage), and the expense of drying to an acceptable moisture level.

Harvesting on time not only reduces shattering losses during harvest, which increase substantially below 13% moisture content, but also reduces pre-harvest losses. Any variety will shatter if left in the field long after pods are mature. Make every effort to harvest within 2 weeks after maturity. A 2-3 week delay can double harvest losses.

Table 2. Harvest Loss Calculations.

Source of Loss	Seeds Found in 10 sq ft Area	÷ 40* =	Your Yield Loss in bu/A	Acceptable Loss in bu/A (40 bu yield)
1. Total Harvest	_____	÷ 40* =	_____	1.3
2. Pre-Harvest	_____	÷ 40 =	_____	0.1
3. Gathering Unit	_____	÷ 40 =	_____	1.1
a. Shatter	_____	÷ 40 =	_____	0.4
b. Loose Stalk	_____	÷ 40 =	_____	0.2
c. Stubble	_____	÷ 40 =	_____	0.5
4. Threshing and Cleaning	(Line 1 - Line 2 - Line 3)	=	_____	0.1

*Number of seeds to equal 1 bu/A loss in a 10 sq ft area. If a 20 sq ft area is used to measure counts, then divide by 80.

Combine Operation and Adjustment

The operator's manual provides basic adjustments for the combine. Use these as a guide and make additional adjustments to meet specific field and crop conditions. The most important items to consider when operating the combine are ground speed, reel speed, cutterbar height, and the threshing and cleaning process.

Ground speed will influence gathering losses more than any other factor. Although the combine can be satisfactorily operated at speeds of 2 to 4 miles per hour (mph), a recommended ground speed of 2½-3 mph normally results in the lowest harvesting losses.

As ground speed increases beyond 3 mph, the cutter bar does not move fast enough to cut plants smoothly and more shattering occurs; the cutterbar pushes plants forward before they are cut resulting in stripping of pods; the impact of the reel is greater which increases shattering; and the operator keeps the cutter bar higher resulting in more pods left on the stubble. An uneven stubble height is an indication of excessive ground speed.

A reduced ground speed (less than 2 mph) in weed infested fields helps to reduce harvest losses in the threshing and cleaning processes by not overloading the combine and allowing more efficient threshing, separating, and cleaning of the soybean seed.

The **reel** holds the soybeans over the cutter bar for cutting and then moves them onto the platform apron. However, reel contact should be minimized since it is also responsible for shattering losses. Reel speed should be adjusted with ground speed to avoid excessive shattering. For best results, reel speed should be about 1.25 times the combine ground speed.

For machines with fixed reel drive assemblies, the relative reel speeds are too fast at low ground speeds and too slow at high ground speeds, thus increasing shattering at both extremes. If too fast, the reel will flail the stalks, cause shattering, and throw stalks over the reel. If too slow, it may drop stalks or allow them to be recut.

The reel should also be positioned to cause a minimum disturbance of standing plants and to reduce shattering and stalk losses. The center shaft of the reel should be positioned 6 to 12 inches ahead of the cutter bar and should be run just deep enough into the soybeans to gain control of the stalks. If reels are too low, stalks will be carried on the reel and dropped. For lodged soybeans, a faster reel speed and a pickup type reel are preferred to ensure the plants are lifted and positioned in front of the cutterbar before they are cut. Newer combines equipped with variable reel speed drives and reel position controls permit rapid adjustments of reel speed and position to meet changing crop conditions.

Cutting parts should be properly maintained for efficient cutting and to minimize shatter losses. Keep knives sharp and properly adjust the knife sections, guards, and wear plates.

Soybeans should be cut as close to the ground as possible to avoid leaving pods on the stubble and also to avoid shattering pods by cutting them. For best results, a cutting

height of about 2-3 inches is recommended. This may require special equipment such as a floating cutterbar or an automatic header control which permit the cutterbar to follow the contour of the ground and cut the plants lower. Cutting heights above 4 inches may substantially increase stubble losses.

Cylinder speed and concave clearance are the two most important adjustments on a combine for quality threshing. The operator's manual should be used as a guide for adjusting cylinder speed, concave clearance, sieve settings, and fan adjustment for cleaning. As moisture content and field conditions change, adjust settings to prevent over or underthreshing. Overthreshing causes excessive seed damage (splitting, cracking, seedcoat damage) while underthreshing leaves seeds in the pods. Cylinder speed and concave clearance should be set to properly remove seeds from the pods. Soybeans generally require lower cylinder speeds and wider concave spacings compared with other crops.

Cylinder speeds ranging from 400 to 800 rpm are normally adequate. Higher cylinder speeds of 700-800 rpm cause greater seed damage than speeds of 500 rpm. It may be necessary to use a cylinder speed lower than 500 rpm if excessive seed damage occurs. Concave clearance may vary from 3/8 to 1 inch. Use as much air as possible to remove material without blowing seeds out with the material.

Increasing cylinder speed and decreasing concave clearance result in more seed damage, particularly at lower moisture contents. Soybeans with higher moisture contents require more energy to remove the seed from the pod; therefore, the cylinder speed should be higher and the concaves set closer. As the soybeans dry out, the cylinder can be slowed and the concaves opened. The fan may also have to be slowed as moisture content drops. The adjustments demand constant attention and are a compromise between threshing losses and seed damage. Adjustments may need to be made several times daily as moisture content changes.

Weeds, particularly green material, place a greater burden on the threshing process and increase threshing and cleaning losses. Material should be moved through the combine slowly for a better job. This is best accomplished by reducing ground speed rather than making cylinder and concave adjustments.

Equipment Options

Header equipment and accessories developed within the last 10-15 years have substantially reduced harvesting losses as compared to the older, conventional fixed cutterbar. These newer types have reduced harvesting losses to as low as 2-4% of the yield.

The **floating and/or flexible headers** allow the cutterbar to follow the ground contour and result in closer cuts and lower stubble heights. Research has shown header losses to be reduced by 25-30% as compared to those with the rigid cutterbar. Most combine manufacturers now offer built-in flexible bars. Add-on attachments can be purchased for older combines.

Row crop headers employ gathering mechanisms similar to those used in a corn header. These headers reduce

harvest losses as much as 50% over conventional headers. They are also designed to operate at faster ground speeds than conventional headers with no additional increase in harvest losses. Their disadvantages are that they cost more, cannot cut drilled soybeans, and cannot harvest many other crops.

Headers equipped with **quick-cut knives** have been shown to reduce harvest losses and can also be operated at higher ground speeds. These headers have double the number of sickle blades and guards at closer spacings which increases the number of cutting surfaces. Shattering losses are reduced because stalk movement is reduced.

Research results from several tests indicate the following **typical gathering losses**, ranked in order from highest to lowest losses for various header options:

- 1) conventional fixed cutterbar,
- 2) floating fixed cutterbar,
- 3) add-on flexible floating cutterbar,
- 4) original equipment flexible floating cutterbar,
- 5) quick-cut floating cutter bars, and
- 6) row crop headers.

The new **axial flow (or rotary) combines** have been effective in reducing soybean seed damage by one half as compared to conventional rasp bar combines. Grain loss monitors are now available for combines. They aid the operator in knowing what losses are occurring in the combine and in making needed adjustments as conditions change.

Production Practices to Increase Harvest Efficiency

Variety selection is helpful from several standpoints. Selecting varieties of different maturities spreads out harvest time so that harvest for each variety can occur near optimum moisture content to reduce shattering losses. Varieties with lodging resistance are more easily harvested with fewer losses. Also, select varieties that resist pre-harvest shattering. As a rule, earlier varieties shatter more easily than full-season varieties. Varieties also differ in podding height. Those with low podding height have greater stubble losses. As a rule, varieties from later maturity groups have higher podding heights than varieties from early maturity groups. Select earlier varieties for earlier harvest for those fields where conditions may delay harvesting.

Harvest on time when soybeans are ready. Harvest losses can easily double if harvest is delayed 2-3 weeks beyond initial maturity.

Level fields decrease losses by allowing lower cutting heights. Cultivation and ridging should be held to a minimum. Start off with a smooth, level seedbed at planting.

Obtain uniform, optimum stands. Overpopulation increases lodging. Less-than-optimum stands reduce podding height and increase branching which can lead to greater harvest losses.

Narrow rows help reduce stubble losses by increasing podding height. Attachment of the lowest pod on plants in narrow rows is higher than on plants in wide rows. Also, because of better, equidistant spacing of plants in narrow rows, lodging is also reduced if populations are not too high.

Strive for **good weed control**. Weeds increase harvest losses by 5-7% by causing threshing problems and increasing losses at the header. In addition they slow combine operations and add trash and foreign matter to the grain which lowers its quality. Use of desiccants in weedy fields, if applied properly, can aid in harvesting.

For further information see Kentucky Cooperative Extension Service publication AEN-25, "Harvesting, Drying and Storing Soybeans," at your county Extension office.

Drying

On-farm drying and storage of soybeans has four major advantages:

- The crop may be harvested earlier and at higher moisture contents to reduce the possibility of harvest losses;
- Harvesting can proceed at a faster pace since daily harvesting hours can be extended or also occur under less than ideal conditions;
- It can be used as a marketing tool to give the grower flexibility in selling his crop; and
- It allows more of an opportunity for fall field work (tillage or seeding).

Soybeans combined at 14% moisture content or higher should be dried if they are being placed in storage. With adequate drying methods, soybeans could be harvested at a moisture content as high as 20%; however, a good practical compromise for a maximum harvest moisture content is about 18%.

When drying from a high to a safe moisture content, a large amount of water must be removed which directly affects the cost of the drying operation. Since soybeans can lose this moisture rapidly in the field under good weather conditions, they should be harvested (weather permitting) when they have reached approximately 14-16% moisture content for maximum returns. If soybeans can be allowed to field dry, the smaller range of moisture removal (usually less than 5%) required for storage makes them relatively easy to dry compared to other fall-harvested grains.

The most **unusual drying characteristic of soybeans**, however, is the **susceptibility of the seedcoat to cracking** and splitting. The key factor in avoiding seedcoat cracks is to keep the relative humidity of the drying air above 40%. When exposed to air below 40% relative humidity for extended periods, the seedcoat becomes very susceptible to cracking. Since relative humidity is roughly cut in half with each 20 degree temperature increase, this puts a severe limit on safe drying air temperatures to avoid seedcoat cracking.

Example: Consider the case of an air temperature of 70°F and relative humidity of 70%. Increase the temperature to 90°F and the relative humidity drops to 35%. Although the temperature is not exceedingly high, the relative humidity drops below 40% and some seedcoat cracking may occur. High drying temperatures can easily cause a large number of seedcoat cracks and splits.

The safe maximum temperature of the heated air for drying soybeans is determined by the final use of the soybean and also whether the amount of cracks and splits are of concern to the producer. There is a general recommendation that drying air temperatures should not exceed 100°F. However, even at this temperature seedcoat cracks are likely to occur. Therefore, **temperatures not exceeding 85°F are recommended.**

The upper limit generally recommended for soybeans used for seed is 110°F, which is a germination limitation. However, since splits and cracking would be a serious problem for soybeans used for seed, the upper limit for **seed purposes** should also be 85°F. If seedcoat cracking and germination are not important, higher temperatures can be used. However, there is general agreement in the grain trade and soybean processing industry that high drying air temperatures are detrimental to quality of soybean oil and protein. Temperatures should be limited to 130°F for **soybeans to be milled or to be used for food.**

Most drying systems can be used to dry soybeans if proper considerations are given to drying temperatures, relative humidities, and handling practices. The combination of drying air temperature and relative humidity influence on soybean quality and damage is of great importance in the design of a soybean drying, handling, and storage system.

Drying systems that depend on high drying air temperatures for drying capacity are not well suited to the drying of soybeans. The biggest limitation to **batch and continuous-flow drying systems** is the inability to reduce heat input. Most batch and continuous-flow drying systems require more handling of the product than is required for in-bin drying systems, which also makes these systems less desirable for drying soybeans. The advantage of these systems is a high airflow rate and faster drying which would be desirable in wet years with poor drying conditions.

Considering all design factors, **a bin drying system is usually best for drying soybeans.** Low-temperature drying, reduced handling, and less short-term management are advantages of the system. Disadvantages are limited fill depth when drying very wet soybeans.

For purposes of discussion, the various drying systems can be generally classified according to the amount of heat

utilized to dry the soybeans as follows: natural air drying, supplemental heat, and high temperature drying.

Natural Air Systems

Natural air bin drying systems are very efficient for drying soybeans but can be used only with **favorable weather conditions.** Relatively moderate humidity and air temperatures are required. In general, the air conditions should be above 60°F and the humidity below 75%. Unheated air drying will not work in extended periods of damp weather. Special attention should be paid to the management practices for drying soybeans with natural air when excessive moisture or adverse weather is encountered.

The amount of drying that will be accomplished with natural air drying is dependent upon the moisture content of the soybeans and upon the temperature and relative humidity of the air. Since soybeans are hygroscopic (give up or absorb moisture), they will adjust in **moisture content** as they are exposed to air containing higher or lower amounts of moisture.

At a given temperature and relative humidity, there is a corresponding moisture content at which the soybean seed has no tendency to gain or lose water. This is called the **equilibrium moisture content (EMC).** If seed moisture is higher than the EMC, drying of the seed will result. Likewise, if seed moisture is lower than the EMC, then rewetting of the seeds will take place. The practical significance of EMC is that one can determine if seed moisture will increase or decrease in a given environment (temperature and relative humidity).

The EMC of soybeans at various air temperature and relative humidity combinations is given in *Table 3* and can be used as a guide to determine if drying will take place.

Example: *Table 3* indicates that if soybeans with a moisture content of 16% were placed in a bin when the air temperature is 60°F and the relative humidity is 80%, little or no drying would occur without supplemental heat. However, if the relative humidity was 70% at the same air temperature of 60°F, the seed will dry down to about 12.4% moisture content. Thus, operating a fan with no heat when the relative humidity of the air is 70% or less will dry soybeans to a moisture content that is in the range for safe storage for a few months.

The exact amount of **time** required to reach a safe moisture content will depend upon initial moisture content, airflow, and weather conditions (temperature and relative humidity) during the drying period. At high initial moisture contents, weather conditions may not permit enough time to dry the soybeans to a safe moisture content before spoilage occurs without making some adjustments to operating procedure. Thus, supplemental heat may be needed to increase temperature and decrease relative humidity, or bin filling depth may need to be reduced to ensure adequate drying. In a warm, wet harvest season both temperature and fill depth may need adjusting to speed drying.

With natural air drying systems, the amount of moisture (water) to be removed from soybeans will be

Table 3. Equilibrium Moisture Content of Soybeans at Various Temperatures and Relative Humidities.*

Air Temp. (°F)	Relative Humidity, %						
	30	40	50	60	70	80	90
— Moisture Content (%) —							
40	6.9	7.7	8.6	10.4	12.9	16.9	22.4
60	6.5	7.2	8.1	10.1	12.4	16.1	21.9
80	6.0	6.8	7.8	9.6	12.0	15.7	21.1
95	5.7	6.4	7.6	9.3	11.7	15.4	20.6

*For 60°F and 60% R.H., the soybeans will dry to 10.1%.
Source: ASAE Standards, 1992.

increased as bushels (and depths) are increased in bins. At the same time, drying rates are reduced because increased depths reduce air flow rates from fans. Thus, one must be careful not to add more water (in the form of wet grain) than the fans can remove. Otherwise, the soybeans may be damaged by mold growth before they are dried. The minimum air requirements for drying soybeans are in the range of 1 to 1.5 cfm (cubic feet of air per minute) for each bushel of wet grain. If no airflow data are available, a rough estimate is 1000 cfm per fan horsepower.

Supplemental Heat

Soybeans can be dried in most seasons without supplemental heat. During extended wet weather periods, however, a limited amount of heat may be needed to reduce outside relative humidity so the drying process can be completed before mold growth occurs. **The advantages of supplemental heat** are that drying can occur at any time, regardless of weather conditions, and it allows harvest to proceed at normal rates.

Since removal of no more than two to four points of moisture is usually needed, an increase of more than 20°F above outside air temperature is not recommended. In most cases, a 5-15°F increase of air temperature is all that is needed to cause an adequate reduction in **relative humidity**. Too high a temperature will only cause overdrying, cracking, and loss of weight in soybeans. Humidistats may be used to adjust the amount of heat based on the outside relative humidity and should be set at 50% for controlling heaters on soybean drying bins.

With in-bin drying, the rate of drying is controlled by airflow and the final moisture content is controlled by relative humidity. Usually, air flow rates of 2 to 3 cfm/bu and sufficient heat to raise air temperature 5-15°F can be expected to dry soybeans in the time required before spoilage can occur. The exact amount of **time** required, however, will vary with initial moisture content of the soybeans, drying temperature, air flow rates, and outside air conditions. For in-bin drying systems, batch depth and air flow should be matched to initial moisture content of the soybeans. Fans should run continuously if moisture contents are above 16%.

Periodic sampling and moisture checks are useful to determine when drying is completed. If the drying system is turned off before the drying zone has passed through the top surface, spoilage problems may occur. Likewise, it is also easy to overdry soybeans, particularly when the relative humidity of the drying air is less than 40%. Some overdrying of the bottom layer of soybeans can be expected. Using natural air in the daytime under normal conditions and a 5-10°F temperature rise at night will keep the relative humidity in the 50-70% range and is a good operating procedure for soybean drying.

For further information about airflow rates and bin drying systems, see Kentucky Cooperative Extension Service Publications AEN-22, 23, and 56 at your county Extension office.

High Temperature Drying

Increasing temperature in bin depths of 10-12 feet or more with high moisture soybeans and low air flow will not speed drying greatly and can severely overdry the bottom layers.

With high moisture content soybeans, bins should be filled and dried in **layers**. If more drying capacity is needed, stirring devices, portable batch or continuous flow dryers can be used.

However, these dryers may not be capable of operating below the 100-120°F temperature range. Temperatures should be limited to 130-140°F if possible and the soybeans should be monitored closely for damage if these dryers are used. If damage (seedcoat cracks) is present in the dried grain, drying temperatures should be adjusted downward or the grain flow rate increased.

Using too much heat in drying soybeans will cause excessive seedcoat cracking, resulting in splits. Studies with high temperatures have shown it is possible to develop almost 100% cracks in less than 5 minutes of exposure time. With incorrect drying procedures, you could end up with 50-100% splits that may be severely discounted. Even if they are not discounted, the cracked soybeans will not keep well in storage and will break easily during handling.

Handling

During harvesting, drying, and storage all handling operations should be done as gently as possible to minimize seed damage. This is particularly important if soybeans are to be saved for seed purposes. Mechanical injury is an important cause of decline in germination and vigor.

Injury results primarily from impacts of the seed with hard surfaces or other seed. The extent of mechanical damage is related to the moisture content of the seed, the velocity of the seed at impact, and the hardness of the surface being hit. Research studies have shown that the drier the seed, the more susceptible it will be to mechanical damage.

Successful handling of soybeans involves:

- avoiding excessive impact of the grain on hard surfaces;
- running conveyors as full and as slow as possible to maintain capacity;
- using retarder boxes in chutes with long drops (>40 ft) to slow the soybeans and lessen the impact; and
- rewetting soybeans with less than 13% moisture prior to handling.

Storage

When the soybeans have been dried to a safe moisture content, they must be kept in a high quality condition if they are to be stored. Before storing **make sure the bin has been cleaned and sanitized**. Clear all trash, old beans, or other grains from the storage area. Spray the bin if needed and repair any damaged bins.

Soybeans must be stored in tight, weatherproof bins with facilities for adequate aeration. One of the most effective measures to maintain soybean quality in storage is to **start with clean soybeans**. Remove excessive trash from soybeans before they are stored. Accumulation of trash in small pockets in the bin can cause heating and spoilage which may lead to mold and insect problems.

Two Principal Factors

The two principal factors involved in the safe storage of soybeans are moisture content and temperature. The amount of **moisture** in soybeans determines whether mold damage will occur. Soybeans should be dried to lower moisture contents than other grains for safe storage. *Table 4* indicates the moisture levels needed for various storage conditions.

Table 4. Moisture Contents for Soybean Storage.

Storage Conditions	Moisture Content
Winter storage only (short term) (Grain temp. under 50°F)	12-13%
Late spring to early summer (6-9 months) (Grain temp. 50-75°F)	11-12%
One year or longer (long-term)	10-11%

Temperature affects the storability of soybeans in several ways. At higher moisture contents, high temperatures promote rapid mold growth and subsequent spoilage of soybeans. As the moisture content of seed increases, the temperature must decrease for safe storage. Low temperatures help offset the effects of high moisture, particularly as it affects the development of molds and insects.

Most common storage **fungi** have a faster growth rate at temperatures above 60°F. As temperatures decrease below this point, fungi growth rate also decreases and is effectively stopped at temperatures below 40°F. Most **insects** that attack seeds in storage have their greatest activity between 70-90°F. Their growth and reproduction decrease as the temperature falls below 70°F and they usually become dormant below 50°F. Also, insect activity is greatly decreased as grain moisture levels are lowered to 12% or less. Very few, if any, stored grain insect problems occur normally in soybeans.

Aeration

After soybeans are put in storage, some means of aeration must be provided to keep them at a cool, uniform temperature so they will remain in a **high quality condition**. The ability of the soybean to lose and regain moisture more readily than many other grains may account for the fact that **moisture migration and condensation** seem to occur more rapidly in soybeans than other grain stored under similar conditions. Since grain is a good insulator, the soybeans placed in the bin, particularly those near the center, tend to remain near the temperature at which they were placed in the bin from a dryer or the field. In contrast, the grain near the bin wall tends to cool to near the average outside temperature.

As outside air temperature turns colder, the temperature differential between soybeans at the center and those near the bin walls produces natural air currents in the bin. The air near the bin wall is cooler and more dense and tends to fall, forcing the warmer air up through the soybeans in the center of the bin where it picks up moisture. As this air nears the top surface of the soybeans in the bin it cools and moisture condenses on the surface of the grain.

This increase in moisture content of the soybeans cre-

ates an environment that enhances spoilage due to mold or insect growth or sprouting when temperatures are favorable. The reverse situation occurs during the summer months. In this case, the moisture condenses near the bottom center of the soybean mass.

Aeration is necessary to equalize temperatures within the bin and to keep the soybeans within 10-15°F of the average monthly outside air temperature. When temperatures are equalized, there is little potential for moisture migration or condensation that may lead to grain spoilage. In the fall, soybeans should be cooled two or three times to bring their temperature to desired levels as the outside air temperature decreases. See *Table 5*.

A good rule of thumb is to operate the **aeration fans** about once a month in the fall to achieve the desired conditions. Aeration should be repeated until the grain mass has been eventually cooled to 35-40°F. The time it takes to completely aerate a bin will depend on the outside air temperature, the depth of the soybeans, and the airflow rate. With an airflow rate of 1 cfm/bu, it will require about 12 hours of fan operation to move a cooling front through the soybeans. If airflow is 1/10 cfm/bu, about 120 hours of fan operation will be required each time the soybeans are cooled. Soybean temperatures should be checked to determine when complete cooling has occurred.

The aeration fan should be run on cool, moderately dry days and not when humidity is high or during rainy periods. A relative humidity between 50 and 70% is desirable for fan operation for reasons discussed earlier (see *Table 3*). However, it is important to **keep the fan operating once an aeration cycle has started**, even if the air relative humidity increases, until the cooling zone has moved completely through the soybeans.

Some short-term fan operation can be tolerated in periods of adverse weather if necessary. An aeration cycle should not be started during a predicted period of rainfall or below freezing weather. Soybeans should not be frozen because they will take longer to warm back up in the spring and may present unloading problems.

Check the grain periodically throughout the winter for any temperature and moisture changes to ensure quality storage. If there are any signs of heating or hot spots, run the fans continuously until these areas have cooled.

Aeration may also be used to warm up the soybeans in the spring if they will be held through July or August. Aeration should be started when average monthly outside air temperatures are 10-15°F warmer than grain temperatures (see *Table 5*). Trying to warm the soybeans too fast by aerating with air more than 10-15°F warmer than the grain temperature can cause moisture condensation within the grain. Once a warming front has been started through the soybeans, fans should not be turned off until the front is pushed completely through the soybean mass in the bin.

Aeration Equipment

A motor driven fan and air duct or perforated floor in the storage facility are needed for aeration. Only 1/10 to 1/4

cfm of air flow per bushel is usually required. Higher rates are satisfactory if drying fans are already installed. The cost of aerating soybeans is relatively small compared to the investment being protected.

Aeration fan controllers are available that will automatically select conditions for fan operation based on outside weather conditions and desired storage moisture content. These controllers essentially combine the information in *Tables 3 and 5* to choose fan operating conditions. Temperature cables may also be used to measure temperatures in remote bin locations and provide information pertinent to fan management.

For more information on aeration, see Kentucky Cooperative Extension Service publication AEN-45, "Aeration, Inspection and Sampling of Grain in Storage Bins," at your local county Extension office.

Marketing

To get the greatest profit from your soybean crop you must give as much attention to marketing as you do to production. Sound marketing practices require careful production and financial planning. Although marketing may seem complex and frustrating at times, your decisions should be made using realistic pricing and financial goals based on available market information.

Marketing decisions involve **pricing and delivery**:

- when you are going to price soybeans,
- how you are going to price them,
- when you are going to deliver them, and
- how you are going to deliver them.

You can improve your marketing decisions through proper use and analyses of marketing information, and you can increase your profits through selecting better pricing and selling strategies. A study of Kentucky seasonal price variations for several grain crops from 1971-85 indicated that soybeans are the most volatile, which emphasizes the need to develop a marketing strategy.

Table 5. Recommended Soybean Storage Temperatures for Various Months.

Month	Average Monthly Outside Air Temperature (°F)	Grain Temperature (°F)
September	70	55-65
October	60	55-65
November	45	40-50
December-February	35	35-45
March	45	40-50
April	60	55-65
May-August	75	55-65

Source: Kentucky Cooperative Extension Service publication AEN-45, "Aeration, Inspection, and Sampling of Grain in Storage Bins."

Marketing Information

Marketing information should play a fundamental role in your marketing decisions. Knowing when and at what price to sell is difficult without adequate information. Markets are influenced by many factors. Any one or a combination of these factors can cause substantial price changes. By becoming knowledgeable about these factors, you can improve your marketing skills.

The first step is to **know the value of your crop before selling it**. Study the market grade requirements, price premiums, and discount schedules for soybeans. Although USDA grades are used as general guides, market grades and discount schedules can vary among buyers. Soybean price variations can develop due to the relationship between quality factors and actual product value.

Price variations result from price discounts or deductions imposed on soybeans that exceed one or more of the quantitative levels allowed for a grading standard. Production, harvesting, storing, and drying practices can affect the quality of soybeans produced. Excess moisture, splits, kernel damage, weed seed, foreign material and low test weight reduce the price received for soybeans.

For the producer, **price is the main aspect of the marketing decision**. It is governed by the supply of and demand for soybeans in the market. However, many other factors such as governmental programs and other market forces also influence supply and demand and therefore price. Here are the **major factors that influence soybean prices**: usage (exports, crush, and seed), stock reports of soybeans and their products, competition of other oil crops, competition of other meal products, foreign production, weather conditions, production and planting intention reports, domestic government programs, and world economic conditions.

These factors interact over time to alter the supply and demand of soybeans, soybean oil, and soybean meal, causing fluctuations in soybean prices. Thus, it is important for you to be knowledgeable about the factors influencing the market so you can make improved marketing decisions. You should be aware of both current and historical market information which can provide estimates and projections of supply and use during past, current, or future years. Analysis of market information can help a producer make an informed judgment about price trends and/or potential price variations due to trends and adjustments in supply and demand factors. Many sources of information are available from the USDA, land grant universities, other public agencies, and the private sector.

Marketing Alternatives

If you gather and analyze soybean marketing information and recognize marketing opportunities you will have several marketing alternatives available to you. You should become aware of all the marketing alternatives available listed below, and have a working knowledge of them and their proper use and application.

However, before you select a marketing strategy, you must know what price you need to break even or make a

profit, or are willing to accept on your crop. This can be determined by knowing your production costs. If you know the cost of your crop, you can then establish a price goal at which the crop is to be sold. The **price goal** should be high enough to cover the costs of production and provide a reasonable return on your investment.

■ **Cash sale at harvest.** Involves hauling soybeans directly to market from the field and accepting the offered price.

Advantages: no planning or thought; no waiting period for payment; knowing the exact selling price; and no storage risks.

Disadvantages: high potential of receiving the seasonal low price; poor use of labor and equipment; and perhaps receiving a discount for moisture.

■ **Store soybeans and sell later.** Grain is conditioned, placed in storage and held for later sale. To determine whether storage is likely to be profitable, you must know your total storage and handling costs which include interest expense, handling costs, shrinkage, insurance, and energy. The market should guide the length of storage, with the expectations of price increases weighed against the cost of holding grain. A “rule of thumb” is that variable costs of farm storage will be about 1.6% of the grain’s value per month of storage.

Advantages: greater delivery flexibility; potential seasonal price gains; flexibility in tax planning; and better use of labor and equipment.

Disadvantages: space requirement for storage; storage risks in maintaining crop quality; additional costs; and delay in payment until the crop is sold.

■ **Government loan support program.** With this method, a grower participates in the government program, places grain in approved storage, and pledges it as collateral for a Commodity Credit Corporation loan. Several options are available:

- the loan can mature and the title to the grain goes to the government;
- the loan can be redeemed and the soybeans sold;
- the loan can be repaid early with interest and another marketing alternative used; or
- the loan can be repaid at the announced marketing loan repayment level and if the U.S. price is below an announced level, the producer receives a loan deficiency payment.

Advantages: cash payment upon receiving the loan; establishment of a “floor” price; and option of repaying loan plus interest or forfeiture of grain in lieu of payment.

Disadvantages: cost of conditioning, storing, and maintaining grain; interest cost of loan; and nine-month duration of loan.

■ **Cash forward contract.** Involves a contract signed prior to harvest, for sale of a specified quantity and quality of soybeans at a specified price and delivery period.

Advantages: transfers the risk of lower prices; the producer knows the buyer, price, and delivery point before harvest;

easily understood; no margin money required; and you can potentially lock in a profit by knowing your production costs.

Disadvantages: eliminates benefit of any price increase; eliminates marketing flexibility; and may magnify risks because of production uncertainty.

■ **Delayed pricing contract.** Soybeans are delivered to a buyer, the title changes hands, and the seller agrees to accept a price offered by the buyer at some future date at the seller’s option.

Advantages: flexibility in tax planning; potential price gains may be realized; on-farm storage is not required; and physical storage risk is transferred.

Disadvantages: change of ownership without payment; cash flow implications; time limit on pricing decisions; service charges; and potential buyer default.

■ **Basis contract.** Under this contract the soybeans are delivered to the buyer, the title changes hands, and the seller selects a futures market contract month upon which price will be based. The buyer assigns a “basis” or price differential to the contract and the seller agrees to “price” the contract within a specified period of time.

Advantages: flexibility in tax planning; no on-farm storage; transfer of physical storage risk; and potential partial payment on delivery.

Disadvantages: change of ownership without payment; time limit on pricing decision; potential “basis gain” is eliminated; potential service charges; and potential buyer default.

■ **Hedge-to-arrive contract.** The producer gives the elevator a specific price target for a specific futures contract month. If the market achieves that price, the elevator locks it in for the producer. The flat cash price is negotiated at a later date, either before or after delivery, depending on how the contract was originally written. The market may or may not reach the specific price target but the producer has at least set a price objective.

Advantages: a firm price target or objective is set; you can use the futures market without having to hedge since the elevator does the hedging for you; some chance for upward price mobility; and requires no margin money.

Disadvantages: involves basis risk until the futures target price is reached and the producer converts the contract to a flat cash price; no price protection unless the target price is reached; and rising prices are overlooked since a price is locked in.

■ **Using the futures market.** Futures markets involve a system of trading in contracts for deferred commodity delivery. The futures market may provide soybean producers an opportunity to obtain a return for storage while avoiding some of the risk associated with adverse price changes. Futures markets are a sophisticated method of trading in contracts for deferred commodity delivery; to be used effectively they require a high level of knowledge.

A **futures contract** is an agreement between two parties to buy and sell at a specified time in the future an agreed

amount of a commodity at a specified price. Typically the product doesn't change hands. Nevertheless, it is a firm and binding agreement.

Those who purchase or sell futures contracts have little intention of accepting or making soybean delivery. The seller simply buys back an equivalent contract prior to maturity and the buyer sells back an equivalent contract. Farmers should never trade in the futures market expecting to make or take delivery. Rather, they should trade contracts in the futures market and apply resulting profits or losses to the cash prices received for their soybeans in transactions at local markets.

The key to understanding the futures market is an understanding of the behavior and trends of **basis**, which is the difference between cash and future prices. Futures market prices are determined by bidding between buyers and sellers attempting to evaluate all of the factors affecting the supply and demand situation.

As a soybean producer **here's how you can use the futures market:**

1) Within narrow limits, **you can fix the price you will receive at harvest** by selling futures contracts in an amount equal to the quantity of crop you expect to produce. In a sense, the futures market offers an opportunity to produce and sell soybeans at a guaranteed price. It is essential to look at existing future price quotations and determine what they mean in terms of a net price at the local elevator at harvest. This is a matter of understanding basis.

2) **You can fix the price of stored grain** since the futures market bids for grain that will be delivered at various times in the future. Thus, by selling futures contracts, you can lock in a market price and yet retain possession and be paid for storage of the crop.

Together these two methods of using the futures market are termed hedging, in contrast to speculating. **Hedging** enables users of futures markets to protect their cash positions. In commodity markets, such as soybeans, hedging is the act of taking equal and opposite positions in the cash and futures markets, with the expectation that the net result will prevent a loss due to price fluctuations.

For the producer or owner of a commodity traded in a futures market, hedging is a marketing tool. Hedging can be used by soybean farmers to establish the price of a crop before, during, or after harvest and also to establish a price for a crop in storage for later sale. It is a means of minimizing risk of loss due to price fluctuations and also a means of making additional profit because of basis fluctuations.

The **principles of hedging** are reliable because of the relationship between cash prices and future prices. Future prices are generally higher than cash prices because they reflect costs of storage, insurance, and interest for the commodity being carried for future delivery. Cash prices and future prices tend to move up or down together, in response to varying marketing conditions, although they do not always fluctuate by equal amounts. The weakness or strength of the basis for a commodity depends on both the local as well as the general supply and demand for that commodity. In a discount market when the cash price is below the futures

price, a narrow difference is referred to as a "strong basis" and a wide difference is called a "weak basis." Generally a weak basis reflects an oversupply situation.

Advantages for hedging in the futures market include: maintaining ownership and pricing decisions; reducing price risk and minimizing loss potential; extends the marketing year; and potential gain in basis.

Disadvantages: requires greater marketing knowledge; must store and maintain the grain if it is a storage hedge; margin calls can increase interest costs; overlooks rising prices; and production uncertainty.

Another method of using the futures market is to **sell cash grain at harvest and replace it with the purchase of futures contracts for a similar volume**. Thus, the producer essentially retains ownership of a crop he has produced. However, replacing cash with futures is very speculative and in many cases cannot be justified as a sound marketing tool. It is dependent on seasonally advancing futures prices and it assumes that most of the annual basis gain is over (that is, the cash price won't gain relative to the futures price).

Although many producers think of the **soybean futures market** as only a means of pricing grain, it **can also be used to analyze how price trends achieve highs and lows**. The futures market responds to evaluation of information regarding supply and demand and other factors. By analyzing and charting daily and weekly data about the futures and cash markets, you can increase your ability to recognize favorable marketing opportunities. Records of cash and future prices over a period of years can show price and basis patterns over time and indicate typical market patterns.

■ **Agricultural commodity options.** This is a relatively new marketing tool for reducing the risk of price changes. Basically the commodity options market provides purchasers of options the right, but not the obligation, to buy or sell a futures contract at a specified price (called the **strike price**) within a specified time period. The option writer (option seller) is willing to incur an obligation in return for some compensation which is called the option premium. The option buyer pays the option seller a premium to gain the right (to buy or to sell the futures contract at the strike price) granted in the option. Premiums are determined by competitive bidding, can fluctuate daily, and are not refundable.

Options are a marketing alternative which give you the ability to lock in and guarantee a price while still being able to benefit from a higher market. To a soy-bean seller, an option is used to guarantee a minimum price for the commodity. To a soybean buyer, an option is used to protect against higher prices.

There are two basic types of commodity options: a put option and a call option. These are two distinct contracts. A put option is not the opposite side of a call option.

Put options are used to protect a selling price. They give the holder the right, but not the obligation, to sell a commodity futures contract to the option writer (seller) at a preset price (strike price) at any time he chooses during the life of the option. For this right he pays a premium to the put option seller.

Call options are used to protect a buying price. They give the holder the right, but not the obligation, to buy a commodity futures contract from the option writer at a predetermined strike price at any time he chooses during the life of the option. For this right he pays a premium to the call option seller.

Advantages: eliminates price risk; allows taking advantage of rising prices; omits margin requirements; and loss is limited to the premiums.

Disadvantages: entails greater marketing knowledge; requires premiums; and requires buying in 1000 or 5000 bushel increments.

Note: Options trading is more complex than this simplified discussion. It offers many alternatives, each with a different risk level. Before dealing in agricultural options, you need to be aware of their mechanics, alternatives, advantages, and disadvantages.

Marketing Plan

Successful grain marketers have a marketing plan. A marketing plan can take some of the emotion out of grain marketing decisions by promoting the use of logical, orderly marketing techniques. Because no one can consistently predict grain prices accurately, the initial step in developing a marketing strategy is establishing price targets based on costs, cash flow commitments, and yields.

The key to a marketing strategy is deciding how and when to price the crop. Pricing portions of the crop over a period of time using more than one marketing alternative is advisable since prices of soybeans change continually and often dramatically. Selling the crop in increments with the idea of making several sales during the course of the year provides greater flexibility in responding to changing market conditions as well as reducing the risk of pricing a large share of the crop at an unfavorable level.

No single marketing strategy is suited for everyone and no one strategy is best for every year. You face a unique situation with respect to your type of farm, degree of financial stability, marketing skills, and degree of desire to accept different levels of risk and reward. Therefore you must develop a marketing strategy based upon a price objective, your ability and willingness to take a price risk, your production risk, your financial situation, and cash needs. You should then determine which marketing alternative or combination has the greatest chance of success.

A marketing plan cannot guarantee profitable or riskless grain marketing; however, it provides a strong likelihood that grain producers will make sound marketing decisions.

Suggested References and Related Publications

University of Kentucky Publications

- 1) AEN 20 Principles of Grain Storage
- 2) AEN 22 Low Temperature Drying—Methods and Management
- 3) AEN 23 Low Temperature Drying—Use and Limitations
- 4) AEN 25 Harvesting, Drying and Storing Soybeans
- 5) AEN 45 Aeration, Inspection and Sampling of Grain in Storage Bins
- 6) AEN 56 Layer Drying of Stored Grain
- 7) AEN 62 Stirring Devices for Grain Drying
- 8) AGR 128 Soybean Production in Kentucky, Part I: Status, Uses and Planning
- 9) AGR 129 Soybean Production in Kentucky, Part II: Seed Selection, Variety Selection and Fertilization
- 10) AGR 130 Soybean Production in Kentucky, Part III: Planting Practices and Double-Cropping
- 11) AGR 131 Soybean Production in Kentucky, Part IV: Weed, Disease and Insect Control

Other Publications

- 1) *Modern Soybean Production*. Available from American Soybean Association, St. Louis, MO. (For sale only)
- 2) AED-20, *Managing Dry Grain in Storage*. Available through UK Plan Service, Agricultural Engineering Department, Lexington. (For sale only)
- 3) MWPS-13, *Grain Drying, Handling and Storage Handbook*. Available through UK Plan Service, Agricultural Engineering Department, Lexington. (For sale only)

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