# COSTS AND RETURNS ASSOCIATED WITH ON-FARM STORAGE OF CORN, WHEAT AND SOYBEANS

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The dramatic increase in the amount of on-farm grain drying and storage during the past several years can be attributed to several factors: (1) the price variability associated with grain production, (2) the increased market flexibility associated with storage facilities, (3) farmer dissatisfaction with crowded market outlets at harvest, (4) the double-cropping of wheat and soybeans, and (5) the management advantages that accompany a grain storage system.

Changing demand and supply conditions for grain have historically led to severe price fluctuations. In 1972, crop failures in various parts of the world increased the exports of American grain and caused domestic grain prices to soar. More recently, there has been a period of excess supply and reduced prices. This instability in grain prices has prompted policy makers and farmers to consider on-farm storage as one means of reducing price fluctuations. Individual farmers also view storage facilities as a means of increasing their market flexibility in responding to seasonal price changes and as being complementary to livestock enterprises.

Interest in on-farm storage has also been enhanced by changing production practices and crowded market conditions. Double-cropping

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involving wheat followed by no-till soybeans is facilitated by on-farm grain storage which permits earlier harvest of high-moisture wheat, thus extending the soybean growing season and increasing soybean yields. Western Kentucky has traditionally been a grain surplus region, and grain production has expanded more rapidly than have local market outlets. The result has been long delays for farmers at local facilities during the harvest season. These delays are costly since the time required for harvesting is extended, thus increasing harvest losses and reducing the efficiency of machinery and labor.

Producers contemplating the establishment of on-farm storage facilities, or expanding present facilities, need information regarding the probable costs and returns that will be associated with such long-term investments. Recommendations concerning the type of system suited to various sizes of farms and various farming practices are also needed. It is the purpose of this report to provide these cost and return estimates for various sizes of farms under alternative management conditions.

## Method of Analysis

A random sample of 202 farms was drawn from the population of all farms in Christian County, Kentucky. This county was selected as being fairly representative of grain farming in Western Kentucky and contiguous areas. Early results indicated that farms with less than 100 tillable acres had little or no on-farm storage; thus, those farms were deleted from the survey. This resulted in 70 completed and usable questionnaires. It was determined that this did not constitute an adequate sample size since, for purposes of the study, it was considered desirable to develop three representative farms. Therefore, an additional 19 farms were randomly selected from a list of 100 larger grain producers provided by the Christian County Extension agent for agriculture, bringing the total usable sample to 89 farms.

Three representative farms were subsequently developed on the basis of tillable acres, thus permitting analysis of a range in farm size and operational procedures. The three representative farms were: (1) The small farm, 100-175 tillable acres; (2) the mid-size farm, 176-450 tillable acres; and (3) the large farm, more than 450 tillable acres. These ranges were defined on the basis of the sample distribution and through inspection of the raw data.

After stratifying the farms according to tillable acres, the means, medians, modes, and frequencies were computed for the revelant characteristics within each stratum. These statistics were used to assign relative values to each characteristic defined in the three representative farms. A summary of the representative farm data is presented in Table 1.

## Synthetic Cost Analysis

Using the representative farm data obtained from the survey, two grain storage systems were developed for each of the three representative farms. The first system represents current practices and will be referred to throughout this report as the "representative system". The second system was developed on the basis of engineering recommendations, with the objective of designing a least-cost system that would meet harvest requirements and accommodate storage of all grain produced. This latter system is referred to as the "recommended system".

Table 1. Enterprise Characteristics of Representative Farms

| | Item | Farm 1 | Farm 2 | Farm 3 |
|---|---|---|---|---|
| General Variables | Total Acres | 207 | 357 | 1,089 |
| | Tillable Acres | 135 | 290 | 904 |
| | Rented Grain Acres | 25 | 68 | 304 |
| | Acres Double-Cropped | 0 | 76 | 250 |
| | Bushels Storage Capacity | 3,334 | 10,723 | 32,844 |
| | Beef Cattle | 53 | 55 | 160 |
| | Swine | 160 | 380 | 700 |
| Yellow Corn | Acres | 43 | 110 | 375 |
| | Effective Yields (Bu/Ac) | 88 | 95 | 95 |
| | Total Bushels | 3,784 | 10,450 | 35,625 |
| | Bushels Sold From Field | 454 | 3,135 | 14,250 |
| | Bushels Stored On-Farm | 3,330 | 7,315 | 21,375 |
| | Bushels Fed From Storage | 946 | 2,195 | 4,275 |
| | Months Sold | Jan-Feb | Jan-May | Jan-May |
| | Stored Bushels Sold-Pennyrile | 2,384 | 5,120 | 17,100 |
| | Stored Bushels Sold-Ohio Valley | 0 | 0 | 0 |
| Wheat | Acres | 21 | 76 | 250 |
| | Effective Yield (Bu/Ac) | 34 | 37 | 40 |
| | Total Bushels | 714 | 2,812 | 10,000 |
| | Bushels Sold From Field | 0 | 562 | 0 |
| | Bushels Stored On-Farm | 714 | 2,250 | 10,000 |
| | Months Sold | Sep | Sep | Sep |
| | Stored Bushels Sold-Pennyrile | 714 | 2,250 | 7,500 |
| | Stored Bushels Sold-Ohio Valley | 0 | 0 | 2,500 |
| Soybeans | Acres | 63 | 127 | 475 |
| | Effective Yields (Bu/Ac) | 33 | 32 | 32 |
| | Total Bushels | 2,079 | 4,064 | 15,200 |
| | Bushels Sold From Field | 2,079 | 1,219 | 4,560 |
| | Bushels Stored On-Farm | 0 | 2,845 | 10,640 |
| | Months Sold | 0 | Jan-May | Jan-July |
| | Stored Bushels Sold-Pennyrile | 0 | 813 | 3,040 |
| | Stored Bushels Sold-Ohio Valley | 0 | 2,032 | 7,600 |

Fixed and variable costs for each system were computed to provide an estimate of the total annual cost of each system. Annual fixed costs for both types of systems were developed form the University of Kentucky's Department of Agricultural Engineering computer simulation program, BNDZN (Bin design).[1]

Representative systems were developed by providing BNDZN with the design requirements derived from the respective representative farm data. Recommended systems were developed by providing the appropriate design requirements obtained from the computer simulation program CHASE (Corn Handling and Storage Evaluator). CHASE is a computer simulation model designed to provide management information to farmers considering construction of grain systems. The farmer provides the program with the specific parameters of his operation, including: acres, expected yield, width of rows, harvest days, hours in a harvest day, hauling distance to the facility, desired beginning and selling moisture contents, labor wage rate, drying fuel cost, and electricity cost. The program has built-in equipment costs, equipment types, and design data.

CHASE utilizes the data supplied by the producer in the examination of 60 alternative systems, changing first the types of hauling vehicle, then the type of handling system used (either a portable or a transport auger) and, finally, the drying and storage options. Three drying alternatives are examined, including layer, batch-in-bin, and portable or

[1]BNDZN has built in updated prices of various items needed in construction of grain systems. Layer, batch-in-bin or portable dryers may be chosen. Each item has an assumed life and annual repair requirement. Straightline depreciation is assumed, with a zero salvage value. Other assumptions include a charge of 1% for taxes and insurance on each item, and an 8 1/2% interest charge on borrowed money which is repaid evenly over the life of each item, thus resulting in an effective annual interest charge of 4.25%

continuous flow. A no-storage option for the batch-in-bin and portable dryer is also investigated. After comparing the 60 feasible alternative systems, CHASE ranks them according to purchase and annual costs, including labor and basic equipment requirements for each feasible system.

A system developed by CHASE was chosen on the basis of cost, flexibility, and individual farm requirements. Although both BNDZN and CHASE are designed for handling corn, it was determined that no extra requirements would be involved in handling wheat and soybeans with the same system.

After developing fixed costs for each system with the use of BNDZN, variable costs were then estimated. Labor requirements were first obtained for each system from CHASE, and then modified by adjusting for a labor savings coefficient related to having an on-farm grain system. This coefficient was developed under the assumption that farmers without storage would incur an extra hour's delay for each trip to the elevator during the busy harvest season.

Thompson's fan models (Thompson, Peart, and Foster; 1968) were used to estimate fuel and electrical requirements. When furnished data on atmospheric conditions, grain moisture contents, dryer specifications, bin diameter, and grain depth, the fan models calculated running time and a Btu requirement for removing a pound of water from a bushel of corn. Electricity costs were calculated by multiplying running time by the horsepower of the dryer to obtain horsepower hours, which were then converted to kilowatt-hours with the use of standard conversion factors. Use of other electrical devices in each system was also estimated on the basis of the hours required to handle specified amounts of grain and the horsepower of each item used. Finally, an allowance for miscellaneous kilowatt-hours was added to each total electrical use since the margin of error associated with estimating electrical use was relatively large.

Fuel costs were calculated using the Btu/lb of water requirement obtained from the Thompson models for each system and a procedure for calculating fuel requirements developed by Loewer, White, and Overhults (1975). The first step in these calculations involved determining the total pounds of water removed from each bushel dried. Pounds of water removed times the Btu's required to remove a pound of water equaled the Btu requirement for each bushel of grain. Drying with LP gas was assumed to be 80% efficient, and a gallon of LP gas supplies approximately 73,000 Btu's at the 80% efficiency level. Therefore, the Btu's required to dry one bushel, divided by the 73,000 Btu's supplied by a gallon of fuel, yielded the portion of a gallon of LP gas required to dry one bushel.

A final variable cost item calculated for each system was the chemical requirements for insect control. Calculations were based upon the use of a mixture of 57 percent malathion, and Gregory's (1973) recommendation that each bin be sprayed with a half-pint of malathion per 1,000 square feet prior to placing grain into the bin, plus an additional pint for each 1,000 bushels of grain as it is stored.

## Grain Price Patterns

To assess the profitability of alternative grain storage and drying systems, it is first necessary to determine patterns of cash grain prices in major market areas--the Pennyrile and the Ohio Valley. Cash grain prices for No. 2 yellow corn, No. 1 yellow soybeans, and soft winter wheat were gathered for these markets from the weekly "Grain Market News" (1969-76). Monthly prices were computed from the weekly prices, and these prices were used to construct a seasonal index. This index was calculated on a crop-year basis by dividing the average price for each month by the overall average of the monthly prices for the crop-year. The index was then used to generate prices by taking the mean of the harvest month prices for the years 1972-76 for each grain and using that price as a base to compute expected monthly prices for a harvest year. Harvest months were considered to be October, June, and November for corn, wheat and soybeans, respectively.

Tables 2, 3 and 4 present price data for corn, wheat and soybeans, respectively. Each table compares the indexes for the Pennyrile and Ohio Valley and the expected prices for these two regions. The tables provide a quick reference for gross returns to storage for a Christian County producer selling grain in either region. These tables also include estimates of the gross returns for transporting grain grown in the Pennyrile region to markets in the Ohio Valley region.

## Estimating Costs and Returns to Grain Systems

*Returns*. Many factors affect returns to a farm grain drying and storage system. In this study, returns were calculated for (1) decreases in harvest losses associated with the drying capability, (2) returns associated with drying yellow corn, (3) returns associated with seasonal prices, and (4) increases in double-cropped soybean yields associated with earlier harvest of high moisture wheat. These returns were compared with the total annual fixed and variable costs associated with the physical

Table 2. Wheat Price Data

| Month | Pennyrile Index | Ohio Valley Index | Expected Pennyrile Prices | Expected Ohio Valley Prices | Gross Returns to Transportation[a] | Gross Returns to Storage Pennyrile[b] | Gross Returns to Storage Ohio Valley[b] |
|---|---|---|---|---|---|---|---|
| | % | % | $ | $ | $ | $ | $ |
| Jun | 100.0 | 100.0 | 2.87 | 3.07 | .20 | .00 | .20 |
| Jul | 106.9 | 107.1 | 3.07 | 3.29 | .22 | .17 | .42 |
| Aug | 116.6 | 109.7 | 3.35 | 3.37 | .02 | .48 | .50 |
| Sep | 118.0 | 114.8 | 3.39 | 3.52 | .13 | .52 | .65 |
| Oct | 117.4 | 119.2 | 3.37 | 3.66 | .29 | .50 | .79 |
| Nov | 113.7 | 123.7 | 3.26 | 3.80 | .54 | .39 | .93 |
| Dec | 122.3 | 128.9 | 3.51 | 3.96 | .45 | .64 | 1.09 |
| Jan | 117.8 | 119.0 | 3.38 | 3.65 | .27 | .51 | .78 |
| Feb | 121.3 | 119.5 | 3.48 | 3.67 | .19 | .61 | .80 |
| Mar | 114.3 | 114.2 | 3.28 | 3.51 | .23 | .41 | .64 |
| Apr | 106.0 | 102.5 | 3.04 | 3.15 | .11 | .17 | .28 |
| May | 98.8 | 97.1 | 2.84 | 2.98 | .14 | -.03 | .11 |

[a]Returns to transporting Pennyrile grain to the Ohio Valley were calculated by taking the difference between the respective Pennyrile price and the corresponding Ohio Valley price.

[b]Returns to storage for each region represent the difference between the June harvest price of $2.87 in the Pennyrile Region and respective prevailingmonthly prices.

Note: The column headed "expected prices" represents a set of prices generated by multiplying the index number for any given month times the June price, which serves as the base month. Thus, for example, the December Pennyrile index of 122.3 times the Pennyrile June price of $2.87 equals an expected December price of $3.51.

Table 3. Yellow Corn Price Data

| Month | Pennyrile Index | Ohio Valley Index | Expected Pennyrile Prices | Expected Ohio Valley Prices | Gross Returns to Trans-portation[a] | Gross Returns to Storage Pennyrile[b] | Gross Returns to Storage Ohio Valley[b] |
|---|---|---|---|---|---|---|---|
| | % | % | $ | $ | $ | $ | $ |
| Oct | 100.0 | 100.0 | 2.55 | 2.63 | .08 | .00 | .08 |
| Nov | 97.2 | 98.7 | 2.48 | 2.60 | .12 | -.07 | .05 |
| Dec | 103.7 | 105.1 | 2.64 | 2.76 | .12 | .09 | .21 |
| Jan | 99.7 | 100.8 | 2.54 | 2.65 | .11 | -.01 | .10 |
| Feb | 99.5 | 97.7 | 2.54 | 2.57 | .03 | -.01 | .02 |
| Mar | 99.9 | 97.0 | 2.55 | 2.55 | .00 | .00 | .00 |
| Apr | 98.8 | 95.0 | 2.52 | 2.50 | -.02 | -.03 | -.05 |
| May | 100.7 | 97.4 | 2.57 | 2.56 | -.01 | .02 | .01 |
| Jun | 108.6 | 103.9 | 2.77 | 2.73 | -.04 | .22 | .18 |
| Jul | 112.8 | 108.2 | 2.88 | 2.85 | -.03 | .33 | .30 |
| Aug | 116.6 | 111.2 | 2.97 | 2.92 | -.05 | .42 | .37 |
| Sep | 104.7 | 104.4 | 2.67 | 2.75 | .08 | .12 | .20 |

[a]Returns to transporting Pennyrile grain to the Ohio Valley were calculated by taking the difference between the respective Pennyrile price and the corresponding Ohio Valley price.

[b]Returns to storage for each region represent the difference between the October harvest price of $2.55 in the Pennyrile Region and respective prevailing monthly prices.

Table 4. Yellow Soybean Price Data

| Month | Pennyrile Index | Ohio Valley Index | Expected Pennyrile Prices | Expected Ohio Valley Prices | Gross Returns to Transportation[a] | Gross Returns to Storage Pennyrile[b] | Gross Returns to Storage Ohio Valley[b] |
|---|---|---|---|---|---|---|---|
| | % | % | $ | $ | $ | $ | $ |
| Nov | 100.0 | 100.0 | 5.60 | 5.95 | .35 | .00 | .35 |
| Dec | 103.4 | 102.6 | 5.79 | 6.10 | .31 | .19 | .50 |
| Jan | 91.0 | 90.5 | 5.10 | 5.38 | .28 | -.50 | -.22 |
| Feb | 94.9 | 92.3 | 5.31 | 5.49 | .18 | -.29 | -.11 |
| Mar | 97.1 | 95.9 | 5.44 | 5.71 | .27 | -.16 | .11 |
| Apr | 96.4 | 95.1 | 5.40 | 5.66 | .26 | -.20 | .06 |
| May | 102.5 | 100.6 | 5.74 | 5.99 | .25 | .14 | .39 |
| Jun | 112.4 | 110.7 | 6.29 | 6.59 | .30 | .69 | .99 |
| Jul | 110.6 | 110.0 | 6.19 | 6.55 | .36 | .59 | .95 |
| Aug | 113.2 | 112.1 | 6.34 | 6.67 | .33 | .74 | 1.07 |
| Sep | 106.1 | 105.0 | 5.94 | 6.25 | .31 | .34 | .65 |
| Oct | 103.3 | 101.8 | 5.78 | 6.06 | .28 | .18 | .46 |

[a]Returns to transporting Pennyrile grain to the Ohio Valley were calculated by taking the difference between the respective Pennyrile price and the corresponding Ohio Valley price.

[b]Returns to storage for each region represent the difference between the November harvest price of $5.60 in the Pennyrile Region and respective prevailing monthly prices.

structure of each system, the costs of overdrying yellow corn, transportation costs for that grain shipped to the Ohio Valley, and an interest charge on foregone investments.

A modification of the simulation model, CACHE, was used to estimate returns to drying and storage of corn. Representative harvest strategies were derived from farm survey data, and recommended strategies were developed on the basis of engineering data. CACHE was then used to compare corn harvest losses with and without an on-farm grain drying and storage system. Estimates of harvest losses were computed on the basis of an assumed harvester speed, calendar days of harvest, percent moisture decline per day, and beginning moisture content, as derived from previous studies. Byg (1976) indicated that harvest losses for wheat and soybeans increase by approximately 0.2 bushel per acre for every day harvest is delayed past recommended harvest date. This figure was used in the calculations. Gains associated with reduced harvest losses were valued at harvest price, since the additional bushels were included in total bushels stored.

Returns to drying were calculated only for corn, since it was determined that drying was more critical for corn than for wheat and soybeans. There are several reasons for this conclusion. First, drying returns are related to dockage for selling wet grain. The equilibrium moisture content of corn is approximately 17.5% during the harvest season, which is 2% above the base moisture selling level. By comparison, wheat and soybeans can actually reach equilibrium moisture contents at levels below their respective base moisture selling levels. Furthermore, corn dries in the field at a slower rate than do wheat and soybeans. The assumed field drying rate for corn in this analysis is 0.5% per day, compared with a rate of approximately 1.0% per day for wheat and soybeans (Byg, 1976). In addition, corn can be harvested at higher moisture levels than either wheat or soybeans, further increasing both the returns and the costs associated with drying corn.

Actual calculation of returns associated with drying corn was made by comparing strategies with and without an on-farm grain drying and storage system. Wet bushels were calculated for a strategy without such a system, and discounts for selling wet grain were estimated on the basis of shrinkage charts and drying charges used by Christian County's largest market, the Hopkinsville Elevator (1975). The discounted price was compared with the price per bushel which would be received if the grain were dried.

Returns to storage[2] for the various grains were calculated using the expected prices discussed in the preceding section. Monthly returns after the respective harvest months were calculated both for grain sold in the local Pennyrile market and that sold in the Ohio Valley market. Returns to transporting Pennyrile grain to the Ohio Valley were also calculated; since returns for corn were less than transportation costs, it was assumed that no corn would be shipped for sale on that market. Returns to transporting wheat and soybeans to the Ohio Valley, however, were sufficiently high to cover transportation costs. Therefore, data collected in the survey were used to estimate the amounts of wheat and soybeans which would be sold in each region. It was assumed that these same percentages would

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[2]The term "returns to storage," as used in this paper, refers to the changing value of the stored product as a result of monthly price fluctuations during the months following harvest.

be shipped to the Ohio Valley if farmers were using the recommended grain drying and storage systems. This assumption seems reasonable, given the logistical problems associated with transporting larger amounts of grain. Returns to storage for the representative systems were calculated by comparing expected prices at traditional selling times and at recommended selling times. The returns to recommended systems were calculated on the basis of a single recommended selling time, after considering the system's constraints and optimum selling prices.

It was assumed that corn used for on-farm livestock feed was fed at a fairly constant rate over a 10-month period. On the assumption that returns to storage increase at a fairly constant rate, returns at the end of the 10-month period were divided by 2 to compute the returns to corn fed over the entire period. Experienced farmers and extension specialists in the area indicated that if feed grain must be purchased from a local mill, there is a 10-cent per bushel premium over the price paid farmers by the local elevator; thus, a return of 10 cents per bushel on corn stored for feed was also included.

Returns in the form of increased yield of double-cropped soybeans associated with earlier planting were also calculated. Earlier soybean planting is made possible by early harvest of high moisture wheat and drying it in on-farm facilities. Ten years of data collected by Egli (1977) indicate that soybean yields are reduced by approximately 2% for each day that they are planted after June 13. Thus, early planting has a significant impact on total yield.

*Costs*. Overdrying costs are incurred because of shrinkage associated with drying corn for storage to moisture levels below those required by the market. This is necessary, however, if corn is to be stored safely into the spring in Kentucky. In this study, it was assumed that most corn is dried to 14%, while the base requirement for selling is 15.5%. Losses to overdrying were valued at the selling price out of storage. Since no loss in nutritional value is associated with overdrying, fed corn was not charged an overdrying cost.

Another major cost associated with storing grain is the income foregone on investments that could have been made had grain been sold at harvest. An annual return of 6% on short-term investments was assumed, and a 0.5% charge was added to cover property taxes and insurance on the stored grain. An effective interest charge was then computed for the period for which the grain was stored. Since a farmer makes his decision to store grain at time of harvest, it was assumed that the price prevailing at harvest times the bushels harvested would represent the income immediately foregone by the decision to store. Therefore, interest charges were calculated on this amount. Since fed corn is assumed to be fed at a constant rate over a 10-month period, one-half of the 10-month effective interest rate was charged to fed corn.

A final cost assigned to each system was the cost associated with shipping stored grain from the Pennyrile Region to the Ohio Valley. Discussions with agricultural extension specialists resulted in a decision to charge 13 cents per bushel for shipping grain to the Ohio Valley.

*Calculation of net returns*. Gross returns associated with each grain were compared with total costs to obtain net returns for each grain for representative farm systems selling at traditional times and at recommended times. Finally, returns associated with each grain were totaled to allow comparison of the net returns of each grain system.

## Representative Grain Systems

*The small farm*. In designing a grain system for representative farm 1 (the smaller farm), a 3,334-bushel storage bin with a perforated floor and 10-horsepower drying fan were used.[3] This system was designed for use of forced natural air only, with no heating unit built into the fan. Although variable costs of drying are less for this system, and it represents the system commonly used on smaller farms in Christian County, there is some risk associated with drying grain with natural air alone. If high-moisture corn is placed in the structure on top of other corn, a pocket of wet corn can result which may cause loss of all corn in the bin owing to spoilage. Therefore, such a system requires a high level of management to insure proper conditioning of the grain.

A related characteristic of this system affects the rate at which grain can be harvested. In this particular case, the system determines the harvest rate. Since the system involves in-bin, layer drying of grain, each layer should be dry before another layer is placed on top. This may actually require extending the harvest period over a longer time than would be required in the absence of on-farm storage. To obtain all of the

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[3]For information on the annual fixed costs associated with the alternative systems, see Appendix Table 1. Detailed cost data for individual components of the various systems (bins, fans, augers, etc.) are available from the authors on request. They are not included in this report because changing costs render the actual figures quickly out of date.

benefits associated with on-farm storage, a system must be constructed which will condition grain at a rate consistent with the harvester's capabilities.

Total costs for the system (Table 5) for corn and wheat are 26.6¢/bu and 25¢/bu, respectively. Since wheat is stored in the same bin as corn, this requires that corn be sold before wheat harvest. No soybeans were stored on the small farm.

*The mid-size farm.* For representative farm 2, three bins of equal size were constructed. The first bin included a perforated floor and a 10-horsepower fan with heating unit. This bin is designed to dry one day's harvest of grain at a time and then transfer it to one of the other bins for storage. Such a system is commonly referred to as batch-in-bin drying. The remaining two bins are designed with aeration subfloors and quarter horsepower aeration fans to provide moderate aeration throughout the storage period. The system also includes a transport auger for unloading grain into the bins and transferring grain between bins with assistance from the unloading equipment in each bin.

Owing to the design of this type of system, corn must be harvested before soybeans, because corn requires more drying than soybeans. As previously noted, corn will not dry so rapidly in the field or to as low a level as soybeans. Therefore, corn must be batch-in-bin dried and stored in the storage bins. Subsequently, soybeans can be layer dried in the drying bin and stored there. It is assumed that harvest of soybeans will begin at levels that would require some heated air, but as harvest progresses, moisture content will drop to levels at which natural air will

Table 5. Fixed, Variable, and Total Annual Cost Associated with Various Systems for Corn, Wheat, and Soybeans

| Grain | Item | Representative System 1 | Representative System 2 | Representative System 3 | Recommended System 1 | Recommended System 2 | Recommended System 3 |
|---|---|---|---|---|---|---|---|
| Corn | Fixed Cost | $ 772.59 | $1,765.39 | $4,935.85 | $1,207.02 | $1,790.44 | $6,333.75 |
| | Variable Cost | $ 164.14 | $ 375.57 | $2,760.26 | $ 212.40 | $ 545.47 | $4,709.40 |
| | Total Cost | $ 886.73 | $2,140.96 | $7,696.11 | $1,419.42 | $2,335.91 | $11,043.15 |
| | Total Bushels | 3,334 | 7,315 | 21,375 | 3,850 | 10,629 | 35,899 |
| | Cents/Bu | 26.6 | 29.3 | 36.0 | 36.9 | 22.0 | 30.7 |
| Wheat | Fixed Cost | $ 147.93 | $ 331.66 | $1,429,53 | $ 197.44 | $ 404.41 | $1,574.22 |
| | Variable Cost | $ 30.36 | $ 35.65 | $ 423.07 | $ 12.78 | $ 125.66 | $ 922.28 |
| | Total Cost | $ 178.29 | $ 367.31 | $1,852.60 | $ 210.22 | $ 530.07 | $2,496.50 |
| | Total Bushels | 714 | 2,250 | 10,000 | 718 | 2,882 | 10,100 |
| | Cents/Bu | 25.0 | 16.3 | 18.5 | 29.3 | 18.4 | 24.7 |
| Soybeans | Fixed Cost | NA | $ 423.18 | $1,508.29 | $ 566.61 | $ 542.86 | $2,051.63 |
| | Variable Cost | NA | $ 43.04 | $ 377.51 | $ 52.86 | $ 106.79 | $ 551.61 |
| | Total Cost | NA | $ 466.22 | $1,885.80 | $ 619.47 | $ 649.65 | $2,603.24 |
| | Total Bushels | NA | 2,845 | 10,640 | 2,105 | 4,330 | 15,864 |
| | Cents/Bu | NA | 16.4 | 17.7 | 29.4 | 15.0 | 16.4 |

For more detailed information on variable costs, refer to Appendix Table II.

NA - not applicable - no soybeans are stored in this system.

be adequate. That most of the soybeans are double-cropped lends support to the assumption that they would be harvested after corn.

Design of the system also has an effect on the time at which soybeans are sold. To make room for storing wheat in the same system, soybeans must be sold prior to wheat harvest. Wheat is then layer dried in the drying bin and stored there. This practice has a deceptive impact on the proportional allocation procedures used when budgeting costs of the respective grains. Corn seems to bear most of the cost since it moves through the same bin as wheat and soybeans and is assigned some of that cost, plus the entire cost of the bins in which it is stored. Wheat and soybeans actually share the cost of the drying bin since they are both stored in that bin. Therefore, caution should be exercised when interpreting the costs per bushel as presented in Table 5. The costs are 29.3, 16.3, and 16.4 cents for each bushel of corn, wheat, and soybeans, respectively. Although there are problems with this allocation of fixed costs, it was determined that the proportional approach based on bushels was the best alternative since bushels provided a consistent measure. The primary objective in computing annual fixed costs was to develop a consistent method that would lend itself to making comparisons between systems and not necessarily between the grains. This method allows such flexibility; however, the limitations to this approach should be borne in mind throughout the paper.

*The large farm.* The grain system for representative farm 3 provides more flexibility than previous systems due to the drying method used. This system has three 10,948-bushel bins with unloading equipment, aeration subfloors, and aeration fans in each bin. The major distinguishing factor of this system is the portable dryer which has a 400-bushel-per-hour drying capacity. Unlike other drying methods used thus far, this dryer is located outside of the bins, which increases harvest flexibility as well as flexibility regarding which bin to use for the respective grains. This system also includes a bucket elevator and downspouts to each bin, thus increasing the handling capacity over that possible with a transport auger. For this particular system, it is assumed that wheat and soybeans will be stored in the same bin each year. This assumption is no longer determined by the system; rather, the assumption is based on price expectations associated with soybeans and corn. Respective costs per bushel for the corn, wheat, and soybeans stored in this system are 36.0, 18.5 and 17.7 cents.

## Recommended Grain Systems[4]

*The small farm.* To eliminate some of the problems associated with the representative system for the small farm, the recommended system for the small farm includes a heater unit on the dryer and two bins to allow for batch-in-bin drying. Unlike the representative system, this system was designed to permit storing and drying of all grain produced on the small farm in such a way as to facilitate more rapid harvesting. The system also included a transport auger and unloading equipment in both bins. Bin 1 is the smaller bin, with approximately 2,100 bushel capacity, designed to allow storage of all soybeans produced.

Bin 2 is designed to store corn and has a capacity of 3,860 bushels. As with all batch-in-bin systems used in this study, the design mandates

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[4]As previously noted, the recommended systems were developed with the use of the CHASE computer simulation program. Reference to cost data in Tables 5 and 6 may be useful throughout this section.

that corn be harvested, dried, and stored before soybeans, which are layer dried in the drying bin. Another characteristic of the batch-in-bin systems used in this study is that the soybeans must be sold before wheat is harvested so that wheat can be stored and layer dried in the drying bin.

The make-up of this system is dramatically different from it's corresponding representative system, making cost comparisons between the two systems less meaningful. Because of its unusual size, the small 2,100-bushel bin has the highest per bushel purchase price of any bin used in this study. This factor also causes the fixed costs per bushel of wheat and soybeans to be higher than for any other system used in the study. Per bushel annual costs are 36.9, 29.3 and 29.4 cents, respectively, for the corn, wheat, and soybeans handled with this system.

*The mid-size farm.* The recommended system for the mid-size farm is similar to the representative system since it uses batch-in-bin drying and a transport auger for handling grain. The basic difference is that this system handles all grain produced on the farm and does so with two bins instead of the three in the representative system. This system is also equipped to accommodate a more rapid harvest rate than will the corresponding representative system. The storage bin for the recommended system is designed to handle all of the corn produced, whereas in the representative system two bins were used for less corn. By constructing a single larger bin, per bushel purchase cost is reduced. The drying bin is designed to store all of the soybeans (a capacity of 4,290 bushels). The same assumptions used throughout involving harvest and selling of the respective grains from a batch-in-bin system hold for this system.

Economies of size become more apparent when comparing the fixed per bushel cost for the various grains in the representative system and the recommended system. Such comparison is feasible since the systems are quite similar in design. Table 6 reveals that fixed cost for corn drops from 24.1 to 16.8 cents per bushel when using the recommended system. Total annual per bushel costs, are 22.0, 18.4 and 15.0 cents for corn, wheat, and soybeans. The total per bushel cost for wheat in this system is higher than with the representative system owing to the higher drying costs associated with harvest of higher moisture wheat.

Table 6. Comparison of Fixed and Variable Costs for Representative and Recommended Systems

| Grain | Item Cost | Rep 1 | Rep 2 | Rep 3 | Rec 1 | Rec 2 | Rec 3 |
|---|---|---|---|---|---|---|---|
| | | --cents per bushel-- | | | | | |
| Corn | Fixed (Cost) | 21.7 | 24.1 | 23.1 | 31.4 | 16.8 | 17.6 |
| | Variable (Cost) | 4.9 | 5.1 | 12.9 | 5.5 | 5.1 | 13.1 |
| Wheat | Fixed (Cost) | 20.7 | 14.7 | 14.3 | 27.5 | 14.0 | 15.6 |
| | Variable (Cost) | 4.3 | 1.6 | 4.2 | 1.8 | 4.4 | 9.1 |
| Soy-beans | Fixed (Cost) | - | 14.9 | 14.2 | 26.9 | 12.5 | 12.9 |
| | Variable (Cost) | - | 1.5 | 3.5 | 2.5 | 2.5 | 3.5 |

In concluding the discussion of the recommended system for the mid-size farm, it should be pointed out that a low cost system was developed for existing conditions. However, for a farmer with plans for expansion, a more practical system might include a bucket elevator instead of the transport auger. This would allow easier and more rapid handling to newly constructed bins, but it would also increase the annual fixed cost of the system.

*The large farm.* The recommended system for the large farm is very similar to the representative system, but the capacity of the three bins has been increased to 17,734 bushels each from the 10,948 bushels in the representative system. This permits storage of all grain produced. Additionally, a center building has been incorporated to add convenience of operation to this system. The per bushel total costs of the systems are 30.7, 24.7 and 16.4 cents, respectively, for corn, wheat, and soybeans. Per bushel fixed costs for corn decrease from 23.1 to 17.6 cents when shifting to the recommended system. Caution must be exercised when comparing fixed costs for wheat between these systems. It is actually higher for the recommended system because the bin is underutilized when wheat is stored, whereas in the representative system the bin is fully utilized. Total variable costs are higher for the recommended system due to increased drying requirements.

## Returns to Grain Systems[5]

This section discusses the returns to storage and drying of individual grains in the various systems, and total net returns to alternative systems.

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[5]The reader is again cautioned to be cognizant that the approach used in allocating returns is more relevant for comparing grain drying and storage systems than for comparing among the various grains.

*Corn*. In analyzing returns to corn, it becomes apparent that returns to drying and reduction in harvest losses add substantially to total returns. Comparison of these items among systems also reveals their sensitivity to changes in operating procedure. For example, by modifying harvest procedures and storing all of the corn, the mid-size farm gained approximately 190 bushels when using the recommended system and procedures for harvest.

In analyzing net returns to corn, the most striking finding is that the representative systems, selling at times that appear typical, all received negative returns in excess of 22 cents per bushel. Since this estimate depends on several assumptions, the preciseness of the coefficient may be subject to question, but the magnitude of the loss does suggest that under current practices the profitability of storing corn is questionable. When allowing the same representative systems to sell corn at more profitable times, the returns increased in every case, becoming positive for the mid-size and large system. Table 7 also reveals that adopting a recommended system and selling at recommended times would further increase per bushel returns for each system. The most substantial increase occurs with the mid-size farm, largely as a result of the decrease in per bushel fixed costs, but also from reduced harvest losses.

*Wheat*. Representative farms appear to be selling wheat at optimal (recommended) times; thus, returns to wheat storage are positive at rather high levels. Additional factors enhancing the profitability of wheat storage include the following: (1) wheat is sharing the fixed cost of the structure in which it is stored with soybeans; (2) wheat is stored for only 3 months and, thus, incurs a low interest charge of only 4.7 cents per

Table 7. Net Returns to Systems for Corn, Wheat, and Soybeans (Representative and Recommended Systems)

| Grain | | Rep. 1* | Rep. 1** | Rep. 2* | Rep. 2** | Rep. 3* | Rep. 3** | Rec. 1 | Rec. 2 | Rec. 3 |
|---|---|---|---|---|---|---|---|---|---|---|
| Corn | Net Returns | $-749.23 | -391.31 | -1,622.01 | 138.93 | -5,694.70 | 196.20 | -214.63 | 1,308.54 | 2,096.66 |
| | Cents per Bu | -22.5 | -11.8 | -22.2 | 1.9 | -26.6 | 0.9 | -5.6 | 12.3 | 5.8 |
| Wheat | Net Returns | 171.74 | 171.74 | 802.88 | 802.88 | 3,455.40 | 3,455.40 | 153.88 | 1,139.64 | 3,145.84 |
| | Cents per Bu | 24.1 | 24.1 | 35.7 | 35.7 | 34.6 | 34.6 | 21.4 | 40.5 | 31.1 |
| Soy-beans | Net Returns | NA | NA | 321.17 | 2,406.57 | 3,160.60 | 9,801.48 | 583.58 | 4,412.73 | 15,269.57 |
| | Cents per Bu | NA | NA | 11.3 | 84.6 | 29.7 | 92.1 | 27.7 | 101.9 | 96.3 |
| Total Returns to System[a] | | -577.49 | -219.57 | -497.96 | 3,348.38 | 921.30 | 13,453.08 | 522.83 | 6,860.91 | 20,512.07 |

*Representative system selling at traditional time of the year.

**Representative system selling at recommended time.

NA means not applicable, because no soybeans are stored on the small farm.

[a]For more detailed information on costs and returns associated with each grain, refer to Appendix Tables III - V.

bushel; and (3) the actual returns to storing wheat are at a relatively high level of 46 cents per bushel.

Only the mid-size farm showed increased per bushel net returns when adopting the recommended system. The reduction in per bushel wheat returns when the small farm adopts the recommended system centers around the fixed costs of the two systems. As noted earlier, the recommended system has a higher per bushel fixed cost due to its different design. The decline in per bushel returns to wheat when the large farm adopts the recommended system is primarily a result of the increased variable costs associated with extra drying. This should not lead one to dismiss extra drying as uneconomical, however, since the real return to the extra drying of wheat shows up in increased yields of earlier planting of double-cropped soybeans.

*Soybeans*. Data in Table 7 indicate that soybean returns are positive for every system that stores them. This is particularly interesting in view of the fact that gross returns to storage when aggregated for all three crops in the representative systems selling at typical dates, are quite low, and, in the case of the small and mid-size farms, negative. This further underscores the importance of reduced harvest losses and increased double-cropped yields associated with drying wheat. In the representative system for the mid-size farm, the net gain associated with these extra bushels offsets the losses incurred by selling the soybeans at a price lower than harvest price.

Selling soybeans at recommended times dramatically increased returns to the representative farms. Table 7 shows returns to the grain system for the mid-size farm increasing from 11.3 to 84.6 cents per bushel and for the large farm from 29.7 to 92.1 cents per bushel. Returns associated with adopting the recommended systems are positive for soybeans for all three size farms.

*Returns to alternative systems.* Table 7 also summarizes the net returns associated with each system. As expected, returns to representative systems selling at traditional times are lower in every case than returns to the same system when selling at recommended times. In each case, returns to recommended systems are also higher than returns to representative systems. The magnitude of the increase in returns to the representative system when grain is sold at recommended times provides an indication of the sensitivity of each system to grain price variability.

Returns to the representative small farm system are negative, suggesting that it is difficult for a small operator to profit from on-farm storage under current practices. However, by introducing soybean storage and adopting the recommended system, on-farm storage becomes profitable.

As a result of constructing a system to store all of the grain and by changing harvest procedures, the mid-size farm doubles net returns by adopting the recommended system. On the large farm, net returns are increased by approximately $7,000 by adopting the recommended system.

## Summary and Conclusions

As interest in on-farm storage has increased, there has been a growing need for data concerning the costs and returns associated with different types of grain storage facilities. In this study, three representative farms were developed from survey data, and two types of storage systems were "constructed" for each of the three farms. The first system was identified as "representative," since it was developed from survey data and typified current practices. The other system, identified as "recommended," was developed on the basis of engineering recommendations, considering the constraints imposed by the characteristics of each farm. When developing similar but larger capacity systems for the same farms, economies of scale for fixed per bushel costs were realized. It was also found that variable costs increased as recommended systems were developed, primarily as a result of increased drying requirements associated with drying higher moisture grain.

Returns to each grain system were compared with costs associated with storing and drying grain in each system in order to determine the profitability of constructing grain systems. The first phase of estimating returns involved analysis of cash grain price patterns in the Pennyrile and Ohio Valley Regions. This analysis revealed that gross returns to storing corn and soybeans have typically been higher if they are sold in mid- to late-summer, and lowest (even negative) when sold in the early months of the year -- a common practice in recent years. Returns to wheat were highest when sold in December, with peak months occurring from August through February. It was also found that even after allowing for transportation costs, wheat and soybeans could generally be profitably shipped from the Pennyrile to the Ohio Valley. Further findings indicate that Pennyrile wheat prices decline during the fall harvest of corn and soybeans, and this pattern is unique to the Pennyrile Region.

In addition to the returns to storage, other returns associated with the drying capacities of the systems were found to be substantial.

These include direct returns to drying high moisture corn, reduced harvest losses resulting from harvesting higher moisture grain, and increased yields of double-cropped soybeans resulting from earlier planting.

Net returns to representative systems selling at traditional sale times were negative for the small and mid-size farms and quite low for the large farm. When selling at recommended dates, the returns to representative systems increased substantially, but net returns to recommended systems were even higher.

There are many potential implications of the increased interest in on-farm storage. Some indication of how on-farm storage can influence price patterns may be seen in the indexes developed during this study. For corn, wheat, and soybeans, the respective indexes were at low levels for the months that farmers indicated they were selling these farm-stored grains. Although such evidence is not conclusive, it does suggest that on-farm storage is influencing cash grain prices.

It was also found during the study that Christian County farmers are currently equipped to store approximately 73% of their production of corn, wheat, and soybeans on the farm; thus, farmers have more control over their grain than in the past. This newly acquired control increases farmer market flexibility and may significantly modify the way in which farmers have traditionally marketed their grain. On-farm storage increases the number of potential markets and decreases dependence on local markets. It can also facilitate better utilization of forward and future contracts.

These are significant considerations for policy makers. There is evidence to suggest that the recent growth in on-farm storage is not unique to Christian County or even to western Kentucky. If indeed similar trends are occurring nationally, on-farm storage is becoming a factor of considerable importance to the development of national grain policies.

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Appendix Table 1. Allocation of Total Annual Fixed Costs Among Grains

| | Total Annual Fixed Cost | Annual Fixed Cost to Corn | Annual Fixed Cost to Wheat | Annual Fixed Cost to Soybeans |
|---|---|---|---|---|
| Representative System 1 | $ 920.52 | 772.59 | 147.93 | None |
| Representative System 2 | 2,520.23 | 1,765.39 | 331.66 | 423.18 |
| Representative System 3 | 7,873.66 | 4,935.85 | 1,429.53 | 1,508.29 |
| Recommended System 1 | 1,971.07 | 1,207.02 | 197.44 | 566.61 |
| Recommended System 2 | 2,737.71 | 1,790.44 | 404.41 | 542.86 |
| Recommended System 3 | 10,256.59 | 6,333.75 | 1,574.22 | 2,051.63 |

Appendix Table 2. Variable Costs Associated With Various Systems for Corn, Wheat and Soybeans

| System | Grain | Kw-Hr Electricity[a] | Cost | Gallons of LP Gas | Cost | Quarts of Malathion[c] | Cost | Hours of Labor[d] | Cost | Total Variable Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Representative System 1 | Corn | 1488 | $46.14 | NA | $ NA | 1.75 | $ 7.00 | 37 | $111.00 | $ 164.14 |
| | Wheat | 141 | 4.36 | NA | NA | .50 | 2.00 | 8 | 24.00 | 30.36 |
| Representative System 2 | Corn | 972 | 30.12 | 641 | 288.45 | 3.75 | 15.00 | 14 | 42.00 | 375.57 |
| | Wheat[e] | 369 | 11.45 | 16 | 7.20 | 1.25 | 5.00 | 4 | 12.00 | 35.65 |
| | Soybeans | 406 | 12.59 | 21 | 9.45 | 1.50 | 6.00 | 5 | 15.00 | 43.04 |
| Representative System | Corn | 1918 | 59.46 | 5344 | 2404.80 | 11.00 | 44.00 | 84 | 252.00 | 2760.26 |
| | Wheat | 910 | 28.22 | 573 | 257.85 | 5.00 | 20.00 | 39 | 117.00 | 423.07 |
| | Soybeans | 959 | 29.71 | 444 | 199.80 | 5.50 | 22.00 | 42 | 126.00 | 377.51 |
| Recommended System 1 | Corn | 477 | 14.80 | 348 | 156.60 | 2.00 | 8.00 | 11 | 33.00 | 212.40 |
| | Wheat | 154 | 4.78 | NA | NA | .50 | 2.00 | 2 | 6.00 | 12.78 |
| | Soybeans | 310 | 9.61 | 45 | 20.25 | 1.25 | 5.00 | 6 | 18.00 | 52.86 |
| Recommended System 2 | Corn | 1586 | 49.17 | 934 | 420.30 | 5.50 | 22.00 | 18 | 54.00 | 545.47 |
| | Wheat | 436 | 11.41 | 205 | 92.25 | 1.75 | 7.00 | 5 | 15.00 | 125.66 |
| | Soybeans | 738 | 20.94 | 93 | 41.85 | 2.00 | 8.00 | 12 | 36.00 | 106.79 |
| Recommended System 3 | Corn | 3174 | 98.40 | 9300 | 4185.00 | 18.00 | 72.00 | 118 | 354.00 | 4709.40 |
| | Wheat | 894 | 27.73 | 1719 | 773.55 | 5.50 | 22.00 | 33 | 99.00 | 922.28 |
| | Soybeans | 1362 | 42.21 | 732 | 329.40 | 7.50 | 30.00 | 50 | 150.00 | 551.61 |

[a]Electricity charged at .031c/Kw-hr.

[b]LP gas charged at .45¢/gal.

[c]Malathion charged at $4.00/qt.

[d]Labor charged at $3.00/hour

[e]Wheat and soybeans in batch-in-bin systems are initially dried with heat. As moisture content drops, forced air is all that is used.

NA means not applicable due to air drying.

Appendix Table 3. Costs and Returns Associated with Corn When Utilizing Alternative Systems

| RETURNS | Rep. 1 | Rep. 1* | Rep. 2 | Rep. 2* | Rep. 3 | Rep. 3* | Rec. 1 | Rec. 2 | Rec. 3 |
|---|---|---|---|---|---|---|---|---|---|
| Bushels gained from reduced harvest losses[a] | -4.3 | -4.3 | 117.81 | 117.81 | 843.75 | 843.75 | 61.49 | 297 | 1117.5 |
| Returns From reduced losses at $2.55/bu | $-10.97 | $-10.97 | $ 300.42 | $ 300.42 | $2151.56 | $2151.56 | $ 159.80 | $ 757.35 | $2849.63 |
| $/Acre return to drying | 3.37 | 3.37 | 3.63 | 3.63 | 3.49 | 3.49 | 3.31 | 3.53 | 5.18 |
| Returns Associated with drying | $128.06 | $128.06 | $ 279.51 | 279.51 | $ 785.25 | $ 785.25 | $ 142.33 | $ 388.30 | $1942.50 |
| Returns to Storage (¢/bu) | 0.0 | 21.0 | 0.0 | 42.0 | 0.0 | 42.0 | 42.0 | 42.0 | 42.0 |
| Bushels sold from storage | 2384 | 2384 | 5120 | 5120 | 17100 | 17100 | 2904 | 8434 | 31624 |
| Returns to storage | $ 0.0 | $500.64 | $ 0.0 | $2150.40 | $ 0.0 | $7182.00 | $1219.68 | $3542.28 | $13282.08 |
| Bushels fed, valued at 30.5¢/bu | 946 | 946 | 2195 | 2195 | 4275 | 4275 | 946 | 2195 | 4275 |
| Returns to fed corn | $288.53 | $288.53 | 669.48 | $ 669.48 | $1303.88 | $1303.88 | $ 288.53 | $ 699.48 | $1303.88 |
| GROSS RETURNS | $405.62 | $906.26 | $1249.41 | $3399.81 | $4237.69 | $11432.69 | $1810.34 | $5357.41 | $19378.09 |

Appendix Table 3. (Continued)

| COST | Rep. 1 | Rep. 1* | Rep. 2 | Rep. 2* | Rep. 3 | Rep. 3* | Rec. 1 | Rec. 2 | Rec. 3 |
|---|---|---|---|---|---|---|---|---|---|
| Cost - Annual, fixed and variable | $ 886.73 | $886.73 | $2140.96 | $2140.96 | $7696.11 | $7696.11 | $1419.42 | $2335.91 | $11043.15 |
| Bu/Ac lost to overdrying | 1.03 | 1.03 | 1.64 | 1.64 | 1.66 | 1.66 | 1.57 | 1.64 | 1.66 |
| Dollar losses per acre (at selling price) | 2.63 | 3.04 | 4.18 | 4.85 | 4.23 | 4.92 | 4.60 | 4.86 | 4.90 |
| Total acres of stored market corn | 27 | 27 | 54 | 54 | 180 | 180 | 32.3 | 87 | 330 |
| Cost to overdrying | $ 71.07 | $ 82.08 | $ 225.72 | $ 261.90 | $ 761.40 | $ 885.60 | $ 148.58 | $ 422.31 | $ 1617.00 |
| Interest charge to stored corn (¢/bu) | 5.5 | 11.1 | 6.9 | 13.8 | 6.9 | 13.8 | 13.8 | 13.8 | 13.8 |
| Cost - interest on sold corn | $ 131.72 | $263.43 | $ 353.28 | $ 706.56 | $1179.90 | $2359.80 | $ 391.64 | $1139.19 | $ 4326.30 |
| Cost - interest on fed cost at 6.9¢/bu | $ 65.33 | $ 65.33 | $ 151.46 | $ 151.46 | $ 294.98 | $ 294.98 | $ 65.33 | $ 151.46 | $ 294.98 |
| TOTAL COST | $1154.85 | $ 297.57 | $2871.42 | $3260.88 | $9932.39 | $11236.49 | $2024.97 | $4048.87 | $17281.43 |
| NET RETURNS | $-749.23 | $-391.31 | -1622.01 | $ 138.93 | -5694.70 | $ 196.20 | $-214.63 | $1308.54 | $ 2096.66 |
| CENTS PER BUSHEL NET RETURNS | -22.5 | -11.8 | -22.2 | 1.9 | -26.6 | 0.9 | -5.6 | 12.3 | 5.8 |

*Each of these systems represent the representative system selling at a recommended time. Representative 1 must sell in June to allow for storage of wheat.

[a]Net gains in bushels as a result of reduced harvest losses are added to total bushels stored in each system.

Appendix Table 4. Costs and Returns Associated with Wheat When Utilizing Alternative Systems[a]

| RETURNS | Rep. 1 | Rep. 2 | Rep. 3 | Rec. 1 | Rec. 2 | Rec. 3 |
|---|---|---|---|---|---|---|
| Bushels gained from reduced harvest losses[b] | 4.2 | 36.6 | 200 | 8.4 | 106.4 | 300 |
| Returns from reduced losses at $2.87/bu | $$12.05 | $ 105.04 | $ 574.00 | $ 24.11 | $ 305.37 | $ 861.00 |
| Total bushels sold in Pennyrile | 714 | 2250 | 7500 | 718.2 | 2882 | 7600 |
| Returns to stored wheat sold in Pennyrile (52¢/bu) | $371.28 | $1170.00 | $3900.00 | $373.46 | $1498.64 | $3952.00 |
| Total bushels sold in Ohio Valley | NA | NA | 2500 | NA | NA | 2500 |
| Returns to stored wheat sold in Ohio Valley (65¢/bu) | NA | NA | $1625.00 | NA | NA | $1625.00 |
| GROSS RETURNS | $383.33 | $1275.04 | $6099.00 | $397.57 | $1804.01 | $6438.00 |
| COST | | | | | | |
| Cost - Annual, fixed and variable | $178.29 | $ 367.31 | $1852.60 | $210.22 | $ 530.07 | $2496.50 |
| Total bushels stored, interest at 4.66¢/bu | 714 | 2250 | 10000 | 718.2 | 2812 | 10100 |
| Cost - Interest on foregone investment | $ 33.30 | $ 104.85 | $ 466.00 | $ 33.49 | $ 134.30 | $ 470.66 |
| Total bushels trucked to Ohio Valley | NA | NA | 2500 | NA | NA | 2500 |
| Cost - Transportation at 13¢/bu | NA | NA | $ 325.00 | NA | NA | $ 325.00 |
| TOTAL COST | $211.59 | $ 472.16 | $2643.60 | $243.69 | $ 644.37 | $3292.16 |
| NET RETURN | $171.74 | $ 802.88 | $3455.40 | $153.88 | $1139.64 | $3145.84 |
| CENTS PER BUSHEL NET RETURNS | 24.1 | 35.7 | 34.6 | 21.4 | 40.5 | 31.1 |

[a]Representative systems were selling at recommended times, therefore there was no need to break them down as with corn and soybeans.
[b]Net gains in bushels as a result of decreased harvest losses are added to total bushels stored in each system.
NA means not applicable.

Appendix Table 5. Costs and Returns Associated with Soybeans When Utilizing Alternative Systems

| RETURNS | Rep. 2 | Rep. 2* | Rep. 3 | Rep. 3* | Rec. 1 | Rec. 2 | Rec. 3 |
|---|---|---|---|---|---|---|---|
| Bushels gained from reduced harvest losses[a] | 54 | 54 | 266 | 266 | 25.2 | 101.6 | 570 |
| Returns from reduced losses at $5.60/bu | $ 302.40 | $ 302.40 | $1489.60 | $1489.60 | $ 141.12 | $ 568.96 | $3192.00 |
| Bu/Ac increase due to earlier planting | 2.14 | 2.14 | 2.85 | 2.85 | NA | 4.99 | 4.29 |
| Total acres double-planted, wheat/soybeans | 76 | 76 | 250 | 250 | NA | 76 | 250 |
| Total bushel increase | 162.6 | 162.6 | 712.5 | 712.5 | NA | 379.24 | 1072.0 |
| Returns from earlier planting $5.60/bu | $ 910.56 | $ 910.56 | $3990.00 | $3990.00 | NA | $2123.74 | $6003.20 |
| Returns per bushel to stored b shels in Pennyrile (¢/bu) | -20 | 69 | 3.7 | 69 | 69 | 69 | 69 |
| Total bushels sold in Pennyrile | 813 | 813 | 3040 | 3040 | 1579 | 2165 | 7932 |
| Returns to stored soybeans sold in Pennyrile | $-162.60 | $ 560.97 | $ 112.48 | $2097.60 | $1089.51 | $1493.85 | $5473.08 |
| Returns per bushel to stored bushels sold in Ohio Valley (¢/bu) | 17 | 99 | 31.3 | 99 | 99 | 99 | 99 |
| Total bushels sold in Ohio Valley | 2032 | 2032 | 7600 | 7600 | 526 | 2165 | 7932 |
| Returns to stored soybeans sold in Ohio Valley | $345.44 | $2011.68 | $2378.80 | $7524.00 | $ 520.74 | $2143.35 | $7852.68 |
| GROSS RETURNS | $1395.80 | $3785.61 | $7970.88 | $15101.20 | $1751.37 | $6329.90 | $22520.96 |

Appendix Table 5. (Continued)

| COST | Rep. 2 | Rep. 2* | Rep. 3 | Rep. 3* | Rec. 1 | Rec. 2 | Rec. 3 |
|---|---|---|---|---|---|---|---|
| COST - Annual, fixed and variable | $ 466.22 | $ 466.22 | $1885.80 | $1885.80 | $ 619.47 | $ 649.65 | $2603.24 |
| Cents/bu charge to interest | 12.1 | 22.8 | 18.2 | 22.8 | 22.8 | 22.8 | 22.8 |
| Total bushels stored | 2845 | 2845 | 10640 | 10640 | 2105 | 4330 | 15864 |
| COST - Interest on foregone investment | $ 344.25 | $ 648.66 | $1936.48 | $2425.92 | $ 479.94 | $ 987.24 | $3616.99 |
| Total bushels trucked to Ohio Valley | 2032 | 2032 | 7600 | 7600 | 526 | 2165 | 7932 |
| COST - Transportation at 13¢/bu | $ 264.16 | $ 264.16 | $ 988.00 | $ 988.00 | $ 68.38 | $ 280.28 | $1031.16 |
| TOTAL COST | $1074.63 | $1379.04 | $4810.28 | $5299.72 | $1167.79 | $1917.17 | $7251.39 |
| NET RETURNS | $ 321.17 | $2406.57 | $3160.60 | $9801.48 | $ 583.58 | $4412.73 | $15269.57 |
| CENTS PER BUSHEL NET RETURNS | 11.3 | 84.6 | 29.7 | 92.1 | 27.7 | 101.9 | 96.3 |

*These systems represent recommended selling times for the representative systems (Representative System 1 does not store soybeans, therefore it is not included).

[a]Net gains in bushels as a result of reduced harvest losses are added to total bushels stored in each system.

NA means not applicable since the small farm does not have double-cropped soybeans.