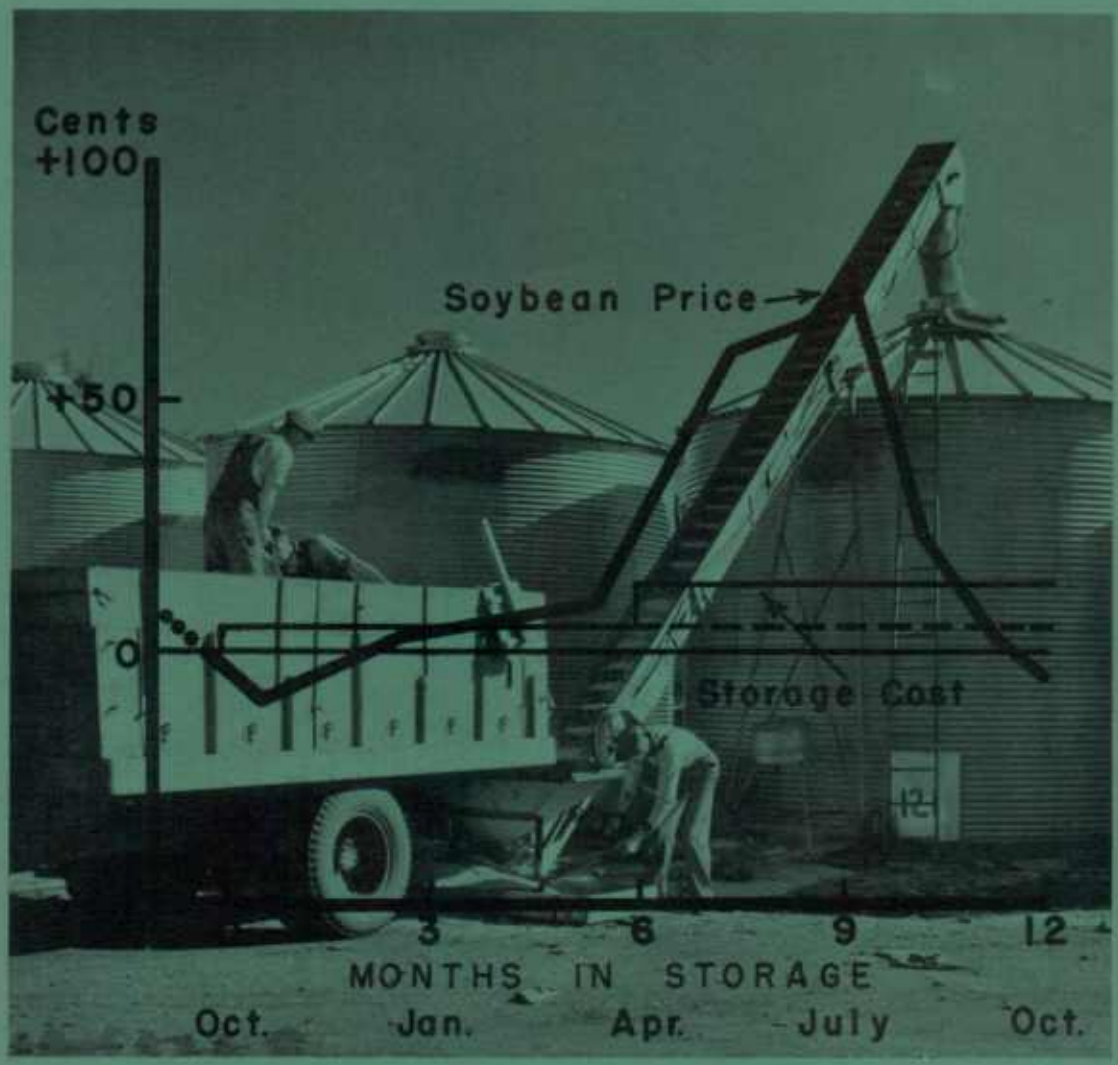
Improving Soybean Marketing Through Farm Storage



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FOREWORD

The Research and Marketing Act of 1946 provides for cooperation among Federal research agencies and industry for the development of research to improve marketing, declaring that a prosperous agriculture requires a sound, efficient, and privately operated system for marketing and distributing agricultural products. Fundamental in the farmer's soybean-marketing role is his planning of a marketing schedule and his use of facilities for harvesting, handling, storing, and transporting the soybeans by that schedule. The producer will obtain the most favorable returns only if his facilities and practices coordinate his whole soybean marketing process for low costs, good quality, and sale on a favorable market.

The Fats and Oils Branch of the Production and Marketing Administration, using funds available under the act, has been conducting a study to discover whether increased storage by farmers would improve soybean marketing, and to analyze the principal costs and benefits that can be expected.

This report establishes a factual basis for a soybean farmer's decisions regarding investment in storage facilities and for his annual marketing decisions regarding his marketing schedule and the use of his storage facilities.

Credit, insurance, and tax costs were analyzed in Cash Costs of Farm Storage in Marketing Soybeans, published in 1950. Various ways of managing the financing of storage and the risks of storage were also analyzed for their effect on cost and their suitability for use by farmers.

In this report, long-run as well as annual storage costs are analyzed, farm and elevator storage costs are compared, and the usefulness of storage in soybean marketing is demonstrated.

Present farmer practice of selling the bulk of the soybean crop at harvesttime contributes to two principal market problems: First, these major sales are made in what is usually the lowest price period of the year. Second, commercial storage and transportation facilities are congested. Heavy harvesttime sales not only bring the farmers lower prices, but actually tend to maximize the seasonal price fluctuations and increase the risk of price change borne by processors and handlers. Congestion of facilities leads to inefficiencies in the use of storage, transportation, and manpower, and is especially serious in a period of emergency mobilization and freight-car shortage. Both problems affect soybean farmers, as well as the transportation industry, soybean processors, and the users of soybean products.

ACKNOWLEDGMENTS

C. B. Gilliland, Chief of the Research Division, and Donald Jackson, Principal Agricultural Economist, both of the Fats and Oils Branch, assisted materially in the preparation and revision of this report, in addition to their important contributions to the development of the study.

Washington, D. C. June 1951

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SUMMARY

1. Soybean marketing problems include seasonally depressed soybean prices, shortages of freight cars, and congestion of handling facilities at country and terminal elevators at harvest time.

2. These problems are worsened by concentration of the major part of United States soybean production in limited areas, the short harvesting period with rapid accumulation of soybeans at harvest time, and the large volume of soybean sales by farmers at harvest time.

3. Increased soybean storage by farmers ordinarily would earn them extra profits and, especially for on-farm storage, would help reduce serious marketing problems.

4. In 3 of the 4 postwar years, soybean storage paid well. Of the farmers who stored 1500 bushels in each crop year from 1946-47 through 1949-50, those who sold the beans at the average December-January price earned, for the four years, $1800 more than they would have received at harvest time; those who sold at the average March-April-May-June price received $2300 extra; and those who anticipated market changes well enough to sell within 25 cents a bushel of the seasonal peak price received at least $3000 extra. These figures are net gain in sales value for the 4 years, after paying storage costs.

5. Soybeans can be stored on farms with suitable facilities at low cost. Total storage costs for 3, 6, and 9 months are, respectively, about 4.5, 6, and 7 percent of harvest-time prices; peak soybean prices averaged 20 percent more than harvest prices over a 4-year postwar period. Cost differences are small between storing on farms or at elevators; each has its advantages. Total farm storage cost, for soybeans valued at $3 per bushel, ranges from 7.8 to 10.3 cents per bushel for 3 months, from 9.6 to 12.2 cents for 6 months, from 11.3 to 14.0 cents for 9 months, and from 13.0 to 15.8 cents for 12 months. Excluding the charge for use of storage space, farm storage cost ranges from 5.6 to 5.7 cents for 3 months, 7.4 to 7.6 cents for 6 months, 9.1 to 9.4 cents for 9 months, and 10.8 to 11.2 cents for 12 months. Charges for handling and for use of farm storage space, which are unaffected by the level of soybean prices, range from about 3.5 cents to 6.0 cents per bushel.

6. Farmers can control the timing of their soybean sales by controlling quality in the stored soybeans. Poor quality at harvest may keep some farmers from storing their soybeans. Quality deterioration also increases storage costs.

7. Maintaining soybean quality during storage means greater profits for farmers and increased efficienty in processing for crushers and manufacturers. Maintaining the quality begins with care in harvesting and handling, and includes storing clean soybeans (at 12 percent to 13 percent moisture content) in sound storage buildings of weathertight construction.

8. To be stored, soybeans with high moisture content should be dried to 12-percent or 13-percent moisture content, using natural or heated air. Drying should be done at the time of storing or as soon thereafter as possible. Stored soybeans should be inspected frequently.

9. Deterioration in stored soybeans can be costly to farmers, consumers, and the entire soybean industry. To farmers it may mean reduced profits because of lower grade and price discounts, or because deterioration may make it necessary to sell when soybean prices are low; it also means reduced quantities of soybeans to sell from storage. To crushers and refiners deterioration means reduced oil recovery, increased operating costs, and increased refining loss. To manufacturers of soybean products, deterioration means increased difficulties and costs in making oil and protein products; to consumers, it means higher prices and lower-quality products.

IMPROVING SOYBEAN MARKETING THROUGH FARM STORAGE

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INTRODUCTION

The soybean is the principal oilseed crop, measured by volume of production or by farm value, of the United States. Each year since World War II, production of soybeans for beans has exceeded 180 million bushels, with a record 287-million-bushel harvest in 1950. Future soybean crops appear likely to exceed 225 million bushels annually, in the absence of acreage limitations or unfavorable conditions during the growing or harvesting seasons.

Early in World War II, soybean production had doubled from 1939 levels, and in 1942 it exceeded cottonseed production for the first time. Each year during the war, the quantity of soybeans harvested increased, with soybeans continuing to exceed cottonseed in production.

Many factors contributed to this rapid expansion. Soybeans offered farmers a source of cash income between the customary selling times for wheat and corn. Prices of soybeans were maintained during the war at favorable levels relative to other principal crops. Soybean harvesting was mechanized, while the labor shortage for cotton harvesting was acute in many localities during the war. On farms where soybeans replaced part of the cotton or corn acreage, total machinery and labor requirements for planting and harvesting were spread out over a longer period, and peak requirements were reduced. In the Midwest, and more recently in the mid-South, improved varieties resulted in higher yields and lower-cost production through increased efficiency in cultivation and harvesting; new varieties were widely available for planting in areas north and west of the prewar areas of commercial soybean production; the efficiency and capacity of crushing plants increased along with the expanded production.

Much of the rapid expansion in soybean production and soybean product consumption resulted from more than 10 years' research by State agricultural colleges, commercial seed firms, oilseed crushers and product manufacturers, and the U. S. Department of Agriculture. Until recently, soybean research has been principally concerned with problems of production, processing, and utilization, with relatively few studies of broad marketing problems. Most of the research directly affecting soybean farmers has dealt with increasing net yields and reducing production costs.

Many farmers have increased their returns from soybeans by obtaining better yields and reducing cost of production, but relatively few have done so by obtaining better prices. Better prices--and more profitable returns--usually can be obtained by many farmers, however, by taking advantage of seasonal price variation. Soybean growers can avoid selling at depressed harvest-time prices simply by storing the soybeans for later sale. They can provide storage on their farms or they can store at commercial warehouses, if space is available. And while increasing their soybean profits through storage, they will be helping to reduce other serious marketing problems.

HOW STORAGE AFFECTS SOYBEAN MARKETING

Soybeans are marketed much as are the cereal grains, but they are utilized quite differently. More than nine-tenths of the soybean crop harvested each year is crushed for oil and meal. Somewhat less than 10 percent is used for planting seed, and the quantity fed to livestock is almost negligible.

Limited quantities are exported as beans, but crushing is the major essential in soybean marketing. Furthermore, the greater part of soybean oil goes into the manufacture of food products--mainly shortening, margarine, mayonnaise, and salad oil--for which uses it must be refined. Value of the oil varies both with refining loss and final quality.

About nine-tenths of the soybean meal goes into livestock feed, and a minor part is used industrially in plastics, adhesives, and many other products. As a rough approximation, the oil and the meal in a bushel of soybeans usually are of about equal value.[1]

Soybean marketing includes the important role of farmers in planning, storing, and timing soybean sales, as well as the usual functions of crushing, manufacturing, transportation, and numerous ownership changes.

[1] A 60-pound bushel of soybeans yields $9\frac{1}{2}$ to 11 pounds of oil and $46\frac{1}{2}$ to 48 pounds of meal, the primary products.

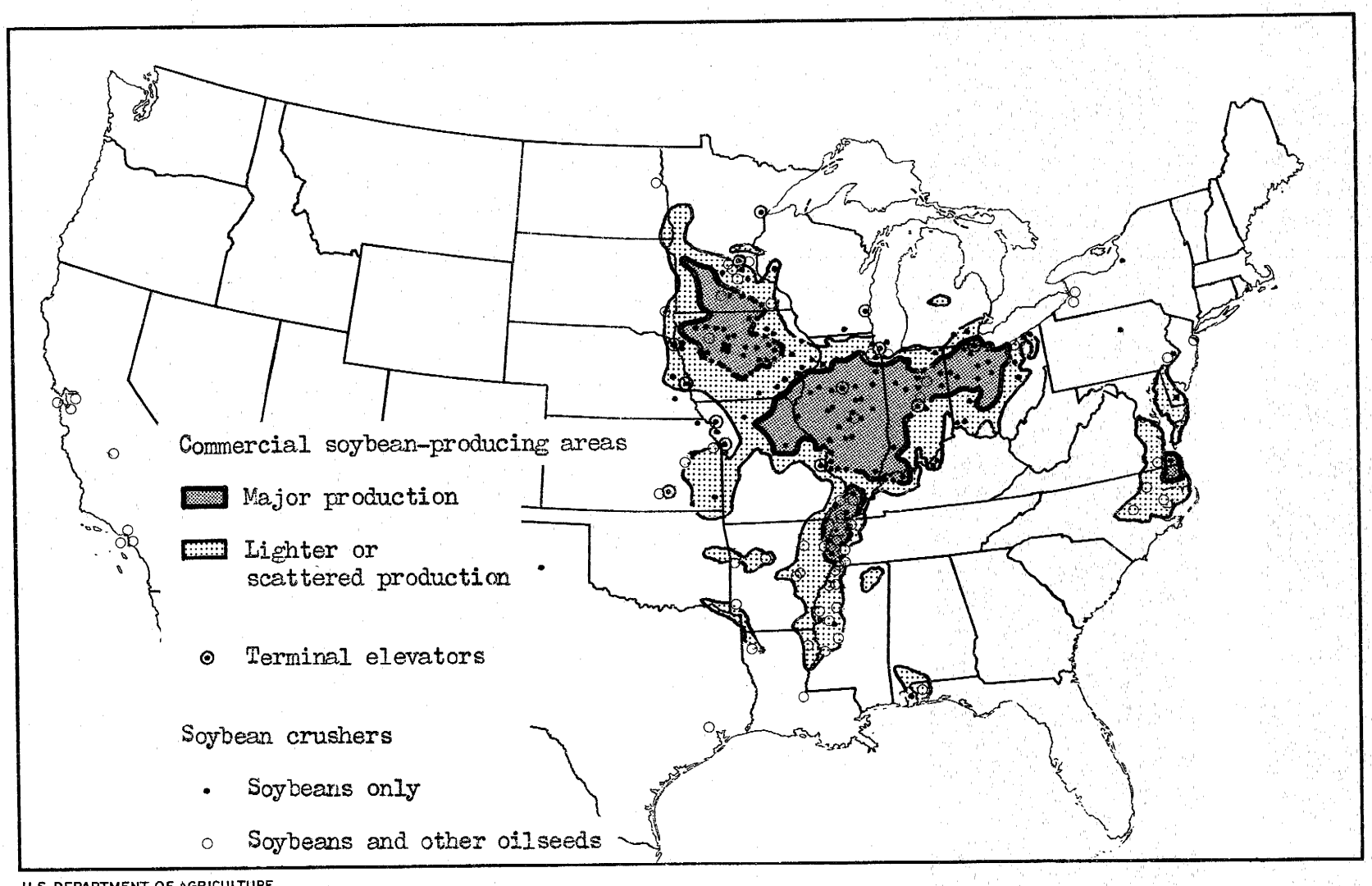

Figure 1--Soybean production and marketing: In marketing, soybeans move typically from farms to nearby country elevators and on to crushing plants; but when this storage is filled, large quantities are shipped to terminal elevators. Most crushers are located in areas of heaviest production, while many terminal elevators are located outside these areas. Crushing for oil and meal is essential to soybean marketing. The products are consumed principally as food or feed.

Prices of soybeans and soybean products swing through a wide seasonal cycle nearly every year, and a major part of the soybeans are marketed by farmers near the low point of the season. About two-thirds of the crop is marketed in October and November. This heavy volume of harvesttime selling contributes to a high seasonal demand for freight cars and results in congestion at country elevators, terminal markets, and processing plants every autumn.

In marketing, soybeans move typically from farms to country elevators and on to processing plants; but as storage space at these locations is filled, large quantities are shipped to terminal elevators (figure 1). For many months, commercial marketing facilities are used for storage of a rather large part of the soybean crop. The rates of soybean crushing and of soybean product consumption are much more nearly uniform from month to month than the rate of farm marketings of soybeans.

Storage to Improve Marketing

Marketing of soybeans can be improved by reducing the seasonal peak in sales by farmers and by spacing farmers' marketings more uniformly throughout the year. Improved soybean marketing schedules could be expected to reduce seasonal congestion of handling and transportation facilities, wasteful back-hauling from terminal elevators to processing plants, and the wide seasonal spread in prices of soybeans and their products. Rigid price controls would be another method for reducing the seasonal price fluctuation, but such controls during World War II encouraged harvest selling rather than storage and resulted in increased congestion at elevators.

Depressed soybean prices at harvesttime reflect the excess of soybeans offered for sale relative to amounts buyers wish to purchase; this involves both crushers' inventory risk,[2] and, by midharvest, the inability of country elevators to ship or to store the soybeans as rapidly as they are delivered from farms. As products of soybeans and cottonseed compete for many uses, soybean prices reflect also seasonally low prices for cottonseed; the same factors are involved. Farmers can avoid both price-depressing influences by storing their soybeans rather than selling at harvest. Refiners and manufacturers of oilseed products have similar inventory-risk problems. Some investigators feel that increased soybean storage by farmers may be expected to help reduce inventory risk.[3]

Farmers' direct interest in more orderly soybean marketing lies in the varying net profits obtainable from different marketing schedules. Because changes in the pattern of their sales depend on storage, analysis of the costs and returns of storage is important. Both costs and returns are influenced by the condition of the soybeans and their storage requirements. Deterioration in storage can involve extra cost and can result in a lower selling price. Even though the effect of quality differences can be reduced by blending various lots of soybeans in crushing, variations in quality affect soybean values through their influence on processing costs and product yields.

The widespread adoption of improved marketing schedules obviously rests with the farmers themselves, and depends principally on the profitability of storage. In most years, soybean prices rise more than enough to cover storage cost.

Soybean storage paid well in 3 of the 4 postwar years, 1946-47 to 1949-50 (figure 2). In 1948-49, despite falling general prices, soybean prices covered storage costs for 1 and 2 months, and were at profitable levels 10 months, after harvest. During the 11-year prewar period (1930-31 to 1940-41) storage was profitable each crop year except depression or recession years (1930, 1931, and 1937 crops). Although storage cost ordinarily remains fairly stable from year to year, both the level and the seasonal movement of soybean prices varied greatly from one year to another (figure 3). During these years, the seasonal price pattern, the month of peak price, and the spread between low and high prices all varied considerably. Seasonal peak prices averaged about 40 percent higher than harvest prices for the prewar 10-year period and 20 percent higher than at harvest time for the postwar 4-year period. Soybean storage was of doubtful profitability or resulted in a loss only in those years when the general price level declined.

Of the farmers who stored 1500 bushels in each crop year 1946-47 through 1949-50, those who sold the beans at the average December-January price earned $1800 more than they

[2] Inventory risk is the risk of price change between the time of soybean purchase and the time of product sale; it involves the amount of possible price change for all the crushers' soybean stocks which are not covered by oil and meal sales for current delivery, or hedged in other ways. The amount of discounts (under current oil and meal prices) increases as the time interval increases between date of sale and delivery date; and tends to be greater, the greater the seasonal price variation. This appears paradoxical, but it is not. Although inventory risk may at times result in windfall profits from price increases, many crushers prefer to shift the chance of either inventory profits or losses, because large losses might jeopardize continued operation.

[3] Inventory risk and risk-bearing methods involve important problems outside the scope of this report; market analysts are studying both problems.

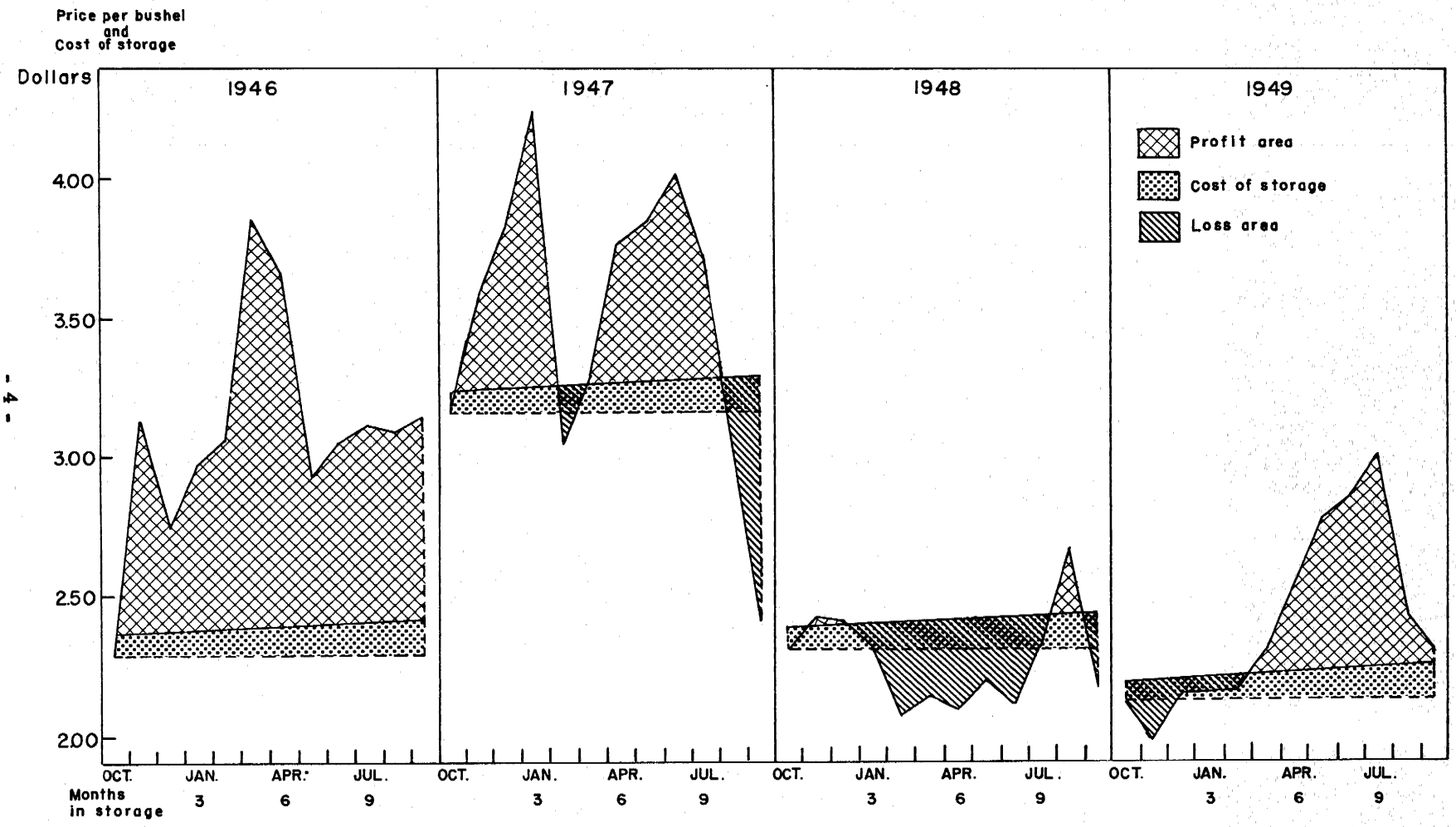

Figure 2--Comparative costs and returns from farm storage of soybeans, Illinois, 1946-49 crops. Prices are midmonth prices ed by farmers, compiled by Bur. Agr. Economics, U. S. Dept. of Agriculture.

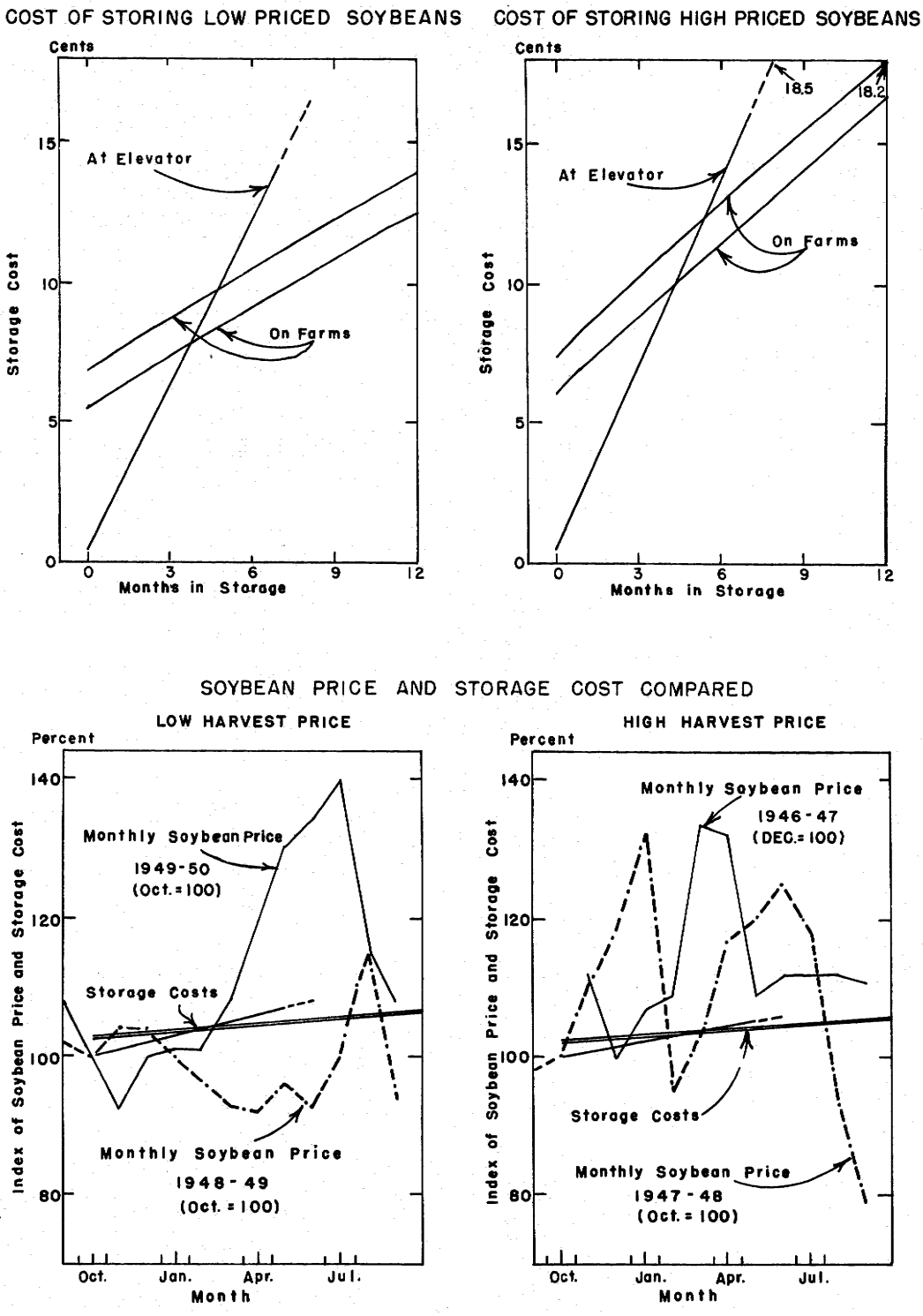

Figure 3--Soybean prices and storage costs. Storage costs vary not only with soybean prices but also with the position of storage and with differences in the cost of farm storage buildings. For storage periods of about 5 months or less, total storage cost is less at elevators than on farms; for about 6 months' to a year's storage, less on farms than at elevators (upper pictures). However, differences in storage cost are small compared with price changes after harvest (lower pictures).

would have at harvest time; those who sold at the average March-April-May-June price earned $2300 extra; and those who anticipated the market well enough to sell within 25 cents a bushel of the seasonal peak price earned $3000 or more. These figures are net profit for holding soybeans in each of the 4 years, after paying storage costs. The seasonal peak prices occurred in March 1947, January 1948, August 1949, and July 1950. Farmers who sold 1500 bushels from storage at peak prices earned $4500 extra. The value of the soybeans at harvest totaled about $15,000 for the 4 years.

Although a uniform rate of soybean sales by farmers could be expected to reduce seasonal price fluctuation, it is unlikely that the variation would be eliminated entirely. Soybean prices reflect the value of their oil and meal equivalents less processing costs, and are influenced by fluctuations in prices of competing products. Soybeans and some of their important competing products probably will continue to be marketed seasonally. Even though the marketing rates for soybeans eventually were to become uniform throughout the year - - which is unlikely - - soybean prices could still be expected to rise enough seasonally to cover storage costs in most years.

Farm Storage or Elevator Storage

Careful comparison must be made in determining the cost advantage of on-farm or off-farm soybean storage. Cost differences are small between storing on farms and at elevators (figure 3 page 5). For storage periods of 5 months or less, total storage costs are less at elevators than on farms; but for 6 months' to a full year's storage, less on farms than at elevators. Once farm storage has been built, however, annual storage outlays are less on farms. After farm storage facilities are once constructed, the most important cost comparison is out-of-pocket cost; building costs already incurred are given less consideration.

In deciding whether to build farm storage, a comparison is needed based on a forecast of total farm storage cost and country elevator storage charges for the following 30 to 40 year period. In deciding whether to store in existing farm storage or at the elevator, the elevator storage charges must be compared with three farm storage costs: in-and-out handling, shrinkage, insurance or risk. In some States, property taxes at both locations must be considered. For some lots of soybeans, conditioning would be necessary for storage at either on-farm or off-farm positions. For some farmers who have to borrow in order to finance storage, the credit cost would also be involved. Credit on elevator-stored soybeans may be easier to obtain or may be less costly; the service fee on a CCC-type loan amounts to $\frac{1}{2}$ cent per bushel for soybeans stored at elevators, 1 cent per bushel for farm-stored beans. The charge for "imputed" interest (interest rate times value of the soybeans) would be the same for farm-stored and elevator-stored beans.

In deciding whether to continue holding elevator-stored beans or to sell, the anticipated price increases must be compared with the monthly storage charge and, in some States, with the amount of tax that would be levied against the soybeans on the tax assessment date. In deciding whether to continue holding farm-stored beans or to sell, costs already incurred can be disregarded. The minimum cost of continuing to hold farm-stored soybeans would be property tax cost on the tax assessment date, for clean soybeans (with 12 percent moisture content) stored in tight bins. There would be no deterioration. If the farmer had not borrowed on the stored soybeans, of course, his interest expenditures would be zero. If in addition he carried their entire physical risk unaided by insurance and incurred no loss from insurable causes, his cash cost for risk would be zero. Loss in handling would be charged in full at the beginning of the storage period, since, after the soybeans have been placed in storage, half the handling loss has been incurred and the other half is inevitable.

Unless farm storage space can be used to full capacity, storing soybeans at country elevators appears less costly than farm storage, at current levels of elevator storage charges. But cost savings are obviously important only to the extent that net returns are increased.

Off-farm storage requires that elevator storage space be available for farmers' use, and that unloading capacity at elevators be sufficient to handle the beans as they are brought in by farmers. Many farmers may feel that the slight extra cost of farm storage is the price of being sure that they will be able to store at all, rather than selling at seasonally depressed prices. As many country elevators limit storage for farmers to 6 months, some farmers may prefer farm storage because of greater flexibility in the time of sale.

Investing in Farm Storage Buildings

Farmers store soybeans in anticipation of increased returns from price improvement. Sabin (44[4]) reports that harvest-time soybean storage by Illinois farmers had increased from 500,000 bushels in 1947 to 5,500,000 in 1948 at 50 country elevators studied. The 1947-48 soybean price pattern had permitted substantial profit for storage either in January or to the

[4]Underscored numbers in parentheses refer to literature cited, page 26.

April-June period (figures 2 and 3, pages 4 and 5). Farmers who store the principal feed grains for better prices may profit from feeding livestock if anticipated price rises do not occur. Because soybeans, unlike feed grains, ordinarily must be sold to realize their market value, there are advantages in storing the beans on the premises of the buyer. These include convenience in financing storage and convenience in selling. Some farmers report storing soybeans at elevators in order to "sell a little bit whenever I need money -- banking at the elevator." Such non-cost advantages as convenience or personal perference may be important factors in influencing a farmer's decision to store on the farm or at the elevator.

Investments in farm storage buildings and equipment, and annual marketing decisions regarding their use, are made mostly in relation to the major crops and enterprises. Although soybeans rank high as a source of farm income, on most soybean-producing farms the principal income source is corn, wheat, livestock, cotton, or truck crops (figure 4). Farms in the cash-grain counties (where the heaviest concentration of soybean production occurs) usually have insufficient storage space to hold all the grains grown, corn excepted. Among the apparent causes are the desire for early cash returns from harvest selling and the reluctance of many farm owners, particularly non-operating owners, to invest more than necessary in buildings. This is because of difficulty usually experienced in obtaining adequate building rental and in recovering book value of buildings when farms are sold.[5] In many leading soybean counties in the Corn Belt and the Missouri-Arkansas Delta, from one-third to one-half the farms are owned by persons other than the operators; and about 90 percent of the soybean production is concentrated in these two areas.

Soybeans and cash grains often must be stored temporarily on farms between harvest and sale. Some country elevators have insufficient space to set any bins aside for warehousing operations for farmers. At others, the storage bins may, by the time of soybean harvest, be full of wheat or oats; or a harvest-time price slump may have increased farmer demand for storage space. And some elevators may temporarily suspend grain and soybean receipts from farmers during the harvesttime rush because of shortage of freight cars for outshipment. Some farmers may find that waiting to unload at the elevator ties up their equipment and manpower so much that they have to suspend harvesting temporarily and gamble on the continuation of good weather.[6]

Whenever farm storage space is available cost considerations favor its use rather than elevator storage, as shown in table 1.[7] And once soybeans are in farm storage, even in temporary space such as crib driveways, it is cheaper to keep them there until time of sale because shrinkage and handling costs have already been incurred.[8]

Increasing their net profit through careful timing of soybean sales is important to all soybean farmers. Only a few can profit from early harvesting; its general adoption would merely cause an earlier seasonal price decline. But many farmers can store soybeans at harvest for sale during the usual price recovery in the winter and spring. Whether to store soybeans or sell at harvest should be decided each year on expected costs and returns for the coming season. Farmers with adequate storage facilities should consider convenience and annual storage costs in deciding where to store. Whether to provide new storage facilities requires a more fundamental study of usual farm storage costs. Adequate storage capacity lends flexibility to farming, but storage facilities, once built, last for many years and must be paid for by the profits from the soybeans and grain stored. Increased farm storage, contributing to more orderly soybean marketing, appears to offer extra profits for many farmers.

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[5] The attitude frequently reported is that a farm with adequate buildings from the farm-operating viewpoint is overbuilt from the farm-sale viewpoint. This influence of the investor-owners on the general farm-sale price causes the operating-owners to take the same viewpoint on buildings which might not bring full value when sold. This is an important factor contributing to the shortage of storage space in localities where it is most needed. However, nonoperating owners can obtain earnings from storage buildings through storing soybeans, sharing use of the buildings with the tenant operator. Book value of the building can be recovered through the profit from storage during the postwar years, the entire investment in storage buildings could have been recovered in the first few years by storing soybeans.

[6] Otten and Richey's data (40) indicated wide variation among Indiana elevators both in the availability of country elevator storage space and in its use by farmers for soybean storage. Hall and associates (19) found that between 60 and 80 percent of the Oklahoma elevators reported having to suspend receiving grain from farmers during the harvest period in 1946 and 1947. Of the 40 percent of the Oklahoma farmers reporting storing on farms, half reported the elevator could not take their wheat; one-seventh could not afford to wait in line at the elevator; one-tenth chose farm storage because of cash cost considerations.

[7] See also Norton (39).

[8] Once half the shrinkage and handling cost has been incurred, the other half is inevitable.

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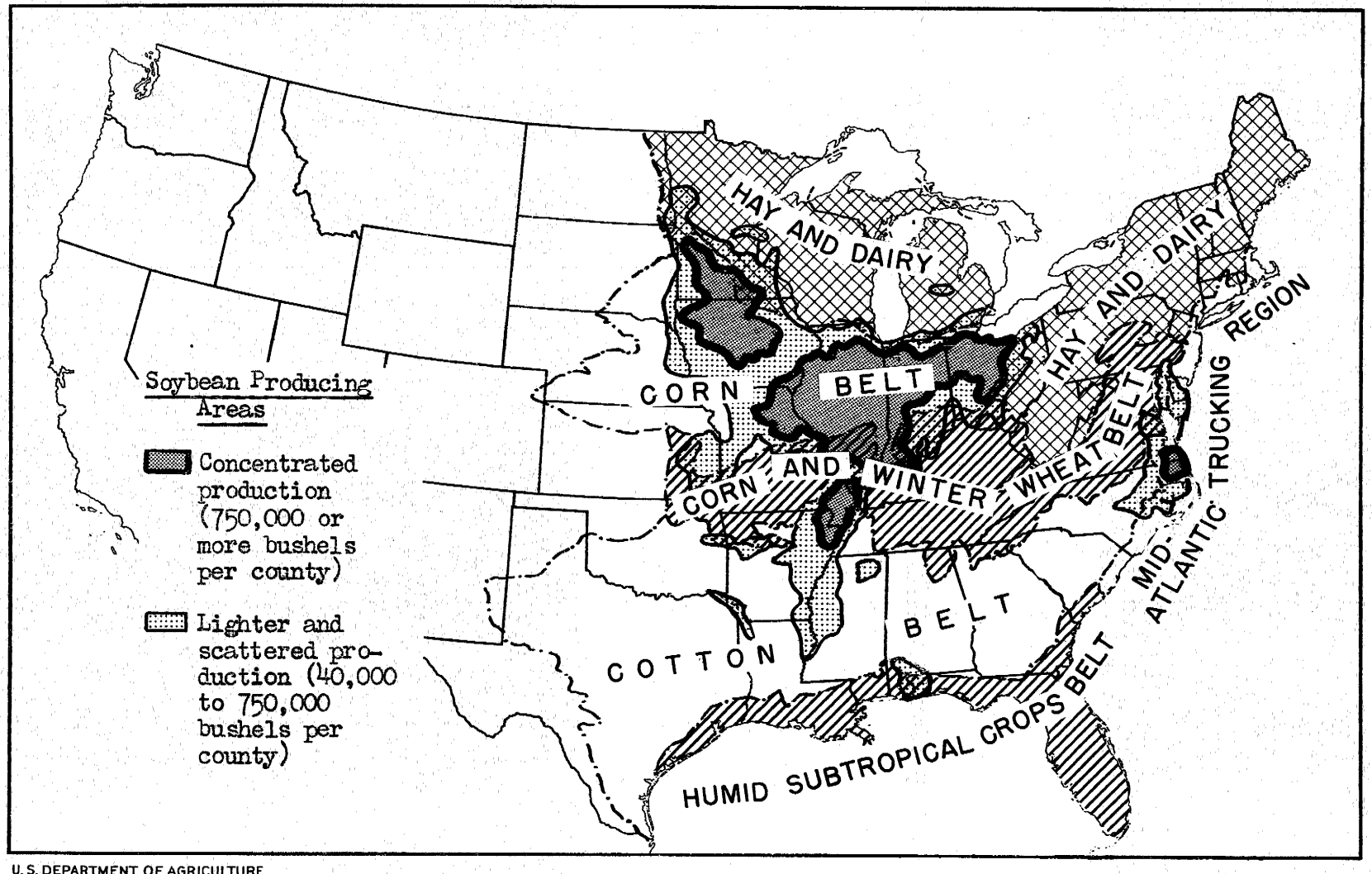

Figure 4--Soybean production in major crop belts: In each crop belt, although soybeans rank high as a source of cash farm income, farmers' investments in storage and drying facilities are generally made for some other crop. In the Midwest, cost and use of crop-drying equipment can be shared by soybeans with corn, wheat or hay. On farms where soybeans would bear the cost alone, many farmers may find it more economical to rely on commercial or cooperative facilities for drying soybeans when needed.

Table 1.--Variation in soybean storage cost with harvest price, type of storage, and length of storage

Soybean price at harvest	Type of storage[1]	Storage cost[2] and length of storage period				
		1st day	3 months	6 months	9 months	12 months
Dollars		Percent	Percent	Percent	Percent	Percent
	Farm:					
1.75-2.25	Medium-cost building	3.5	4.5	5.2	6.7	7.0
1.75-2.25	Low-cost building	2.7	3.5	4.6	6.0	6.2
1.75-2.25	Elevator[3]	.2	3.2	6.2	---	---
	Farm:					
2.75-3.25	Medium-cost building	2.5	3.4	4.3	4.8	6.0
2.75-3.25	Low-cost building	2.0	3.0	3.8	4.3	5.5
2.75-3.25	Elevator[3]	.1	2.3	4.6	---	---

[1]Medium-cost farm storage figures based on investment of 60 cents, constructed, per bushel of capacity; low-cost investment, 40 cents.
[2]Storage cost as percent of harvest price.
[3]Elevator storage for farmers is ordinarily limited to 6 or 7 months.

SOYBEAN STORAGE COSTS

To be a good investment, farm storage facilities must store the crop at a reasonable cost and maintain its quality. Storage cost includes not only the charges for the use of storage space but also the operating costs, whether or not they require annual cash expenditure. Operating costs include shrinkage, handling, loss in quality, and, in some instances, conditioning, which are discussed in this report, as well as interest, insurance, and taxes on the soybeans, which were discussed in an earlier report, Cash Costs of Farm Storage in Marketing Soybeans.[9]

Investment Cost Elements

The charge for the use of storage space represents the gradual return of the investment already made in the building and the annual charges for interest and upkeep of the building. Similar charges for the investment in handling and conditioning equipment are charged to operating costs, along with expenditures for power or fuel and for labor, as explained on page 13.

Depreciation and Interest

Various depreciation methods may be used in determining the amount of the investment which must be charged off annually and the remaining book value of the storage building and machinery (figure 5). The simplest and most convenient method for farm accounting is "straight-line," or "fixed-sum," depreciation, in which a fixed amount is deducted from the valuation each year to reduce the value to zero by the end of the expected useful life of the facility. In the fixed-percentage method, a given percentage of the current or remaining value ("book" value) is subtracted each year as depreciation, the amount thus declining each year. Straight-line depreciation is more useful because the service rendered by buildings does not vary greatly with age. However, some farm appraisers consider percentage depreciation more accurate for measuring actual value and use-cost, especially when based on replacement cost.

Because book value of the building declines with its age, interest as a cost declines also,

[9]A copy can be obtained on request from the Office of Information Services, Production and Marketing Administration, U. S. Department of Agriculture, Washington 25, D. C.

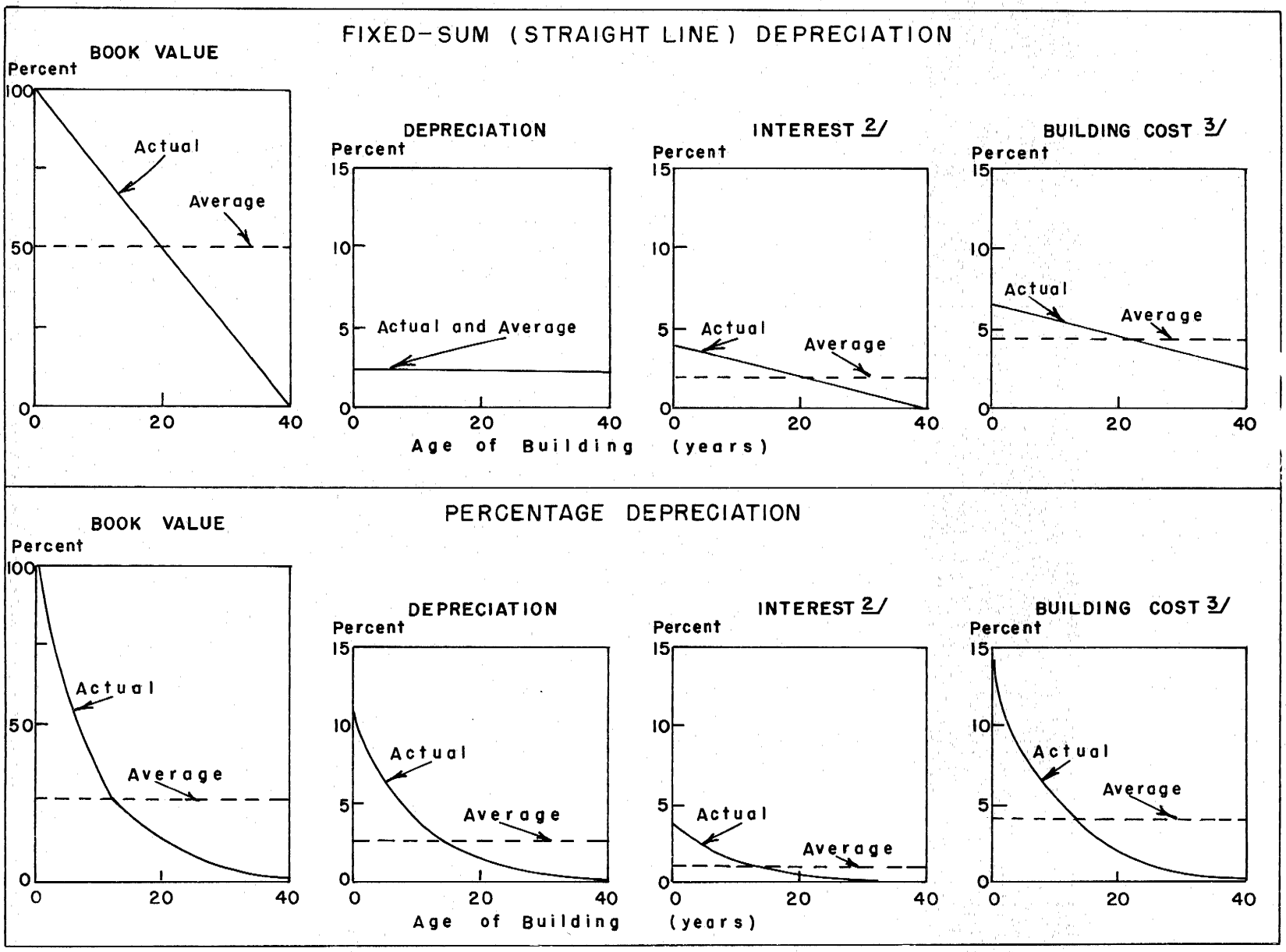

Figure 5--Effect of depreciation method on annual building cost and book value for farm grain storage buildings. Although cost differences apparently result from differences in farmers' bookkeeping methods, annual average "building cost" over the entire useful life of the building is about the same, regardless of the method used.

regardless of the depreciation method. However, an average interest cost figure for practical purposes may be computed by multiplying the interest rate by one-half the original investment.

Taxes and Insurance

It is impracticable to segregate tax costs for individual farm buildings because all of the real estate of the farm is usually assessed together. This problem, therefore, is not peculiar to storage buildings. If a farmer uses some rule-of-thumb method of distributing taxes by buildings, it will serve here, although obviously it may not be exact.

Insurance, or risk cost, (against physical dangers from fire, lightning, wind, or similar forces), varies greatly from one locality to another with the type of insurance and degree of coverage. A farmer usually has a wide choice in the type and amount of insurance, and the kind of policy he can obtain. If he has no loss from the hazards in question, he obviously will save money by not insuring. But he may suffer a severe loss. Insurance cost normally equals the long-time average losses plus the insurance company expenses.

Table 2 shows the ranges and average rates for insurance against wind and against fire and wind on farm grain-storage buildings, for three major soybean-producing regions. These regions in recent years have produced more than 99 percent of the commercial soybean crop of the United States.

Repairs and Renewals

Repairs and renewals are variable expenses that come up at irregular intervals. Some State agricultural colleges recommend, in their farm-accounts service, that the entire cost of major repairs (such as reroofing or painting) be added to book value, and a new depreciation schedule set up to reflect the lengthened useful life of the building. Thus, renewals are accounted for in the same manner as original capital investments.

Ordinary repairs can be ignored when straight-line depreciation is used. Repairs will increase with the age of the building but the heavy cost in the later years may be considered to be offset by the salvage value of materials from the building after the investment has been depreciated to zero.

Types and Costs of Farm Grain-Storage Buildings

Any type of construction is suitable for farm grain-storage (including soybean storage) which meets the following basic requirements (46, 21):

(a) Prevents leakage of the soybeans.
(b) Excludes rain, snow, and ground moisture.
(c) Prevents loss from thieves, rodents, birds, insects.
(d) Permits effective fumigation to control insects.
(e) Provides reasonable safety from fire and wind damage.

Where stored soybeans or other grains[10] are to be sealed as security for price-sup-

[10] Soybeans are technically oilseeds rather than grain; but since they are produced, handled, and marketed like grain, they are commonly referred to as a grain crop.

Table 2.--Annual insurance rates on farm grain-storage buildings, principal soybean-producing regions, 1949

Region	Insurance rates[1]			
	Windstorm and hail		Fire and wind[2]	
	Average	Range	Average	Range
	Percent	Percent	Percent	Percent
Midwest[3]	0.39	0.3 - 0.6	0.95	0.8 - 1.2
Mid-South[4]	.47	.2 - .8	2.03	1.6 - 2.5
Atlantic[5]	.37	.3 - .6	1.20	1.0 - 1.4

[1] Rates as percent of insured value for barns and outbuildings with approved roofing. Averages for the region computed from State averages of soybean-producing counties.
[2] Includes lightning and hail.
[3] Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska.
[4] Arkansas, Kentucky, Tennessee, Mississippi, Alabama, Louisiana.
[5] Delaware, Maryland, Virginia, North Carolina.

Computed from recent recommendations of the respective insurance inspection and rating bureaus.

port loans, the construction must require forcible breaking to be entered after sealing, and must allow sufficient headroom for inspection and sampling.

Any bin of permanent construction which meets these requirements, which can be built at reasonable first cost and low upkeep, and which is convenient for filling and emptying will provide satisfactory and economical storage.

Farm grain-storage buildings of typical design and construction are generally suitable for storing soybeans. Soybeans weigh about the same per unit of volume as wheat or shelled corn. On most soybean farms, the soybean is one of several grain crops which compete to a great extent for the same storage space. Farmers who plan to build additional storage for soybeans or other grain thus have a wide range of choice of materials, design, use, and capacity (46).

The bin over the driveway of a double corncrib, so common in the midwestern corn-soybean region, has a capacity limited by the driveway width, the roof slope, and the crib length. For bins 11 feet wide and $7\frac{1}{2}$ feet deep, common in crib-granaries having 7- or 8-foot cribs, 14-foot eave height, and a roof slope of 1:1 or 3:4, capacity amounts to 60 bushels per foot of length. The 11-foot driveway has a capacity, for emergency storage in shallow layers, of about 15 bushels of soybeans per foot of length, without interfering with proper drying of corn in the cribs on either side. On many farms the size of the corn crop governs the crib dimensions and thus limits small-grain storage capacity.

Smaller, multiple-bin granaries are more common where small grains rather than corn are principal cash crops. In recent years, circular metal bin granaries have become more numerous in some sections.

Single-bin granaries made of lumber range generally from 500 to 2700 bushels in capacity, with 1000, 1200 and 1500-bushel sizes popular. A typical 4-bin granary will store 1800 bushels of grain, and has a hallway which may be used for seed treating and cleaning, or for emergency storage adequate for an additional 800 bushels.

Metal grain storage bins for farm use range in capacity from 500 to about 3350 bushels. Diameters of 14 and 18 feet, and eave heights of 8 and 16 feet are most common. These bins are available from local retail dealers in most of the soybean States. They are made by about 40 manufacturers, with a wide range in special design features. Most manufacturers furnish these bins in several sizes or capacities.[11]

Construction and upkeep costs on farm storage facilities vary with design and with the kind and quality of materials used. For combination crib-granaries construction cost ranges generally from about 60 cents to 90 cents or more per bushel of capacity, excluding elevator; for multiple-bin frame granaries, it ranges from about 55 cents to 75 cents per bushel; and for circular metal bins, about 35 cents to 45 cents. Cost generally decreases as capacity increases. For example, the eave height can be increased without increasing the foundation and roof requirement.

A multiple-bin granary requires more material and labor than a single bin of the same capacity because of the partitions which must be added. Concrete foundations, footings, and floors are common in building crib-granaries; but smaller single multiple-bin granaries are frequently built on skids or supported on concrete-block piers, each costing much less. Foundations for metal bins may range from concrete floors with vapor barriers (18) and footings, to an 8-inch gravel fill enclosed within a metal foundation ring, set about 18 inches in the ground. Concrete block foundation, widely used, is unsatisfactory because empty bins are frequently blown down.

Some farmers may reduce cash expense for construction by using family labor or farm help hired on a year-round basis. Cost of materials for frame construction can often be substantially reduced by using lumber salvaged from old buildings or cut from the farm woodlot, or by remodeling a building (such as a horse barn) no longer needed for its original use.

Annual charges for depreciation and interest on book value vary directly with construction cost and inversely with the useful life of the building. Annual depreciation and interest on a movable bin which has a life expectancy of 10 years and which cost 45 cents per bushel of capacity will amount to 5.4 cents per bushel. This compares with 2.0 cents for a building costing the same but having a life expectancy of 40 years, and 4.0 cents for a crib-granary which cost twice as much to build, per bushel of capacity, and which has a 40-year life expectancy.

Operating Costs of Soybean Storage on Farms

Charges or expenditures for credit, insurance, taxes, shrinkage, and handling are incurred and paid on a single-crop basis. Loss of quality affects principally the value of the soybeans rather than the expenditure. Conditioning affects both the value and the expenditures.

Credit, Insurance, and Taxes

A farmer who stores soybeans will have to decide each year the extent to which he should

[11] Farmers in the midwestern corn-soybean area may also obtain farm grain-storage building plans recommended by the agricultural colleges from the Midwest Plan Service, Iowa State College, Ames, Iowa, or from their State agricultural colleges.

bear the cost of credit, insurance, and taxes (1). The next problem in connection with those costs which he will incur is how to manage them.

Credit cost averages 3 to 6 percent on an annual basis. Storing can be financed by borrowing on the value of the soybeans or by obtaining advances or extensions on production loans; commercial banks, production-credit associations, other credit houses, the Commodity Credit Corporation, and individuals are sources of such loans.

The cost of a loan varies mainly with the source and amount of the loan, the interest rate, and the length of the storage period. "Imputed" interest cost should be charged to stored soybeans when the farmer does not borrow to finance storage. Imputed interest is a proper charge because the farmer usually could obtain earnings from investing the money elsewhere, or net savings from paying off outstanding loans or merchant credit.

Insurance cost averages 0.6 percent on an annual basis, varying with its source and amount, the hazards and coverage that are obtained, and the length of the storage period. Some farmers may feel financially able to carry the entire risk unaided by insurance; others prefer to pool risks through insurance, averaging all losses for many farmers over a period of years.

Tax cost depends on the assessed value of the soybeans and the tax rate; assessed value will necessarily vary with market price and assessment practice. Because soybean prices differ between States and fluctuate during the marketing year, the market price on assessment date shows considerable variation.

In 11 of the 21 principal soybean-producing States, property taxes are not levied against farm-stored soybeans. Among the other 10 States average property tax cost was estimated to range from 0.9 to 11.6 cents per bushel for 1947-48 (1). Average property tax rate was estimated to range from 0.25 percent to 3.8 percent; assessed value ranged from 10 percent to 100 percent of market value; average market value, from $3 to $3.95 per bushel.

In-and-Out Handling

Soybeans stored on the farm may be handled by hand scooping or by mechanical conveyors, or "elevators." Conveyors carry the soybeans by either a screw auger or a series of cups or buckets arranged on endless belts. The cup or bucket elevator is built into a building permanently; many farmers refer to them as "inside" elevators. They are commonly installed in the combination crib-granaries, particularly the larger ones.[12]

Portable "flight-and-chain" elevators, which farmers in some sections call "hikers," use blades instead of cups. Portable augers, frequently used in some areas, require greater care in operation to avoid splitting the soybeans.

Four principal advantages are claimed for portable elevators. They can be moved from one building or farm to another. They generally cost less to buy and operate. They can be used for emptying bins as well as filling them. The flight-and-chain type can be used for handling bagged feed or fertilizer, as well as loose grain, and some also may be used for baled hay.

Among the disadvantages which some farmers report for portable elevators are their shorter useful life, tendency to be easily damaged if blown down or carelessly handled, and less rapid rate of handling grain.

The investment in grain-handling equipment varies not only with the type selected, but with length of the conveyor, the type and gage of metal used, the type of operating power, and special structural features. Portable chain-type elevators range in size from lightweight 12-foot models which a man can carry on his shoulder to reinforced 50- and 60-foot models mounted on wheels. Operating power may be furnished from a gasoline or electric motor, or the elevator may be operated with the farm tractor. In selecting a portable elevator, the length needed depends on the tasks for which it will be used. Both the angle of operation and the height of lift are involved.

The cost of portable flight-and-chain elevators, including discharge spout and tractor take-off sets, ranges from about $420 for a 24-foot length to about $550 for a 44-foot length. Augers generally cost somewhat less. Engines and engine mounts add about $125 to $175 to this cost, after adjusting for cost of the power take-off set. Total cost for both elevator and motor is generally slightly greater for inside than for portable elevators.

Another variable element in the investment in storage facilities is the variety of related equipment, such as truck or wagon hoists, scales, and bin unloaders. These are optional items that save much labor and time. Their economy should be questioned and calculated in each case.

Handling equipment involves the same elements of annual investment cost as the storage building--depreciation, interest, repairs, insurance, and taxes. As the amount of annual depreciation varies with the hours of use, however, the investment cost for handling equipment should be charged to handling cost.

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[12] This helps account for the higher construction cost frequently reported for combination crib-granaries, since the total cost of the storage facility includes the cost of the elevator.

Flight-and-chain type portable elevators have a 1000-hour useful life expectancy for depreciation purposes, and will elevate 300 to 500 bushels or more of grain per hour under typical farm conditions. Portable elevators can handle up to 1000 or 1200 bushels per hour for continuous unloading. The handling capacity given includes allowance for breakage, repair and adjustment; also the rate of grain accumulation, and therefore of unloading, seldom approaches capacity at harvest time under typical farm conditions. Information from manufacturers[13] of portable farm grain handling equipment indicates that total cost, exclusive of labor, ranges from 0.3 cent to 0.5 cent per bushel handled, including depreciation, operation and maintenance, and repair.

Handling soybeans for farm storage involves two special problems which affect cost. First, because soybeans spill back more at steep angles, manufacturers of handling equipment recommend an angle of operation not greater than 30 degrees, and some recommend 20 degrees. This requires a longer elevator for soybeans than for shelled corn or small grain. Second, soybeans have a tendency to lodge under sprockets. At lower moisture contents, this results in splitting; at higher, in broken chains, particularly at the discharge end of the elevator. Some elevators have special design features to overcome this difficulty.

The labor cost of handling soybeans in storage necessarily varies with the wage rate and the quantity handled per hour. At wage rates of $0.75 to $1.25 per hour for labor to operate machinery elevating 300 to 500 bushels per hour, labor cost ranges from about 0.1 cent to 0.4 cent per bushel.

Total cost for both labor and machinery for in-and-out handling thus ranges generally from about 1 cent to 2 cents per bushel, the beans being handled at least twice.

Shrinkage

Shrinkage in storing soybeans is the reduction in quantity resulting from loss of weight as the beans dry out and from loss in handling, either from beans spilled or from particles chipped or rubbed off. For soybeans with initial moisture content of 11 percent, stored in farm-type bins at Urbana, Ill., the weight change during storage was (5) a gain ranging from zero to 0.3 percent for soybeans stored until spring (March, April, May) in every year over a 5-year period. The same range in weight gain was found for storage until June or July in 4 of the 5 years; the fifth year, a year of severe summer drought, showed a weight loss from harvest to June or July of 0.3 percent. The weight gain represented too small an increase in moisture content to affect market grade.

Additional research is needed to determine shrinkage of soybeans for other producing localities, a wider range of initial moisture contents, and for additional varieties, particularly those adapted to all the more important soybean-producing States.

The handling loss in storage varies directly with the care taken in adjustment and operation of the handling equipment. For 70,000 bushels of soybeans stored in farm-type bins at Urbana, Ill., in a study during 1943-47, handling losses were reported as 0.3 percent.[14] Each lot of beans was handled several times, and many batches were dried during the period.

One-quarter of one percent appears a reasonable shrinkage allowance for each handling in storing soybeans on farms, or 0.5 percent for in-and-out handling. This figure also would appear adequate to cover, for many farmers, any weight loss from moisture changes in storage. For emergency storage in temporary facilities, such as crib driveways (page 12), handling losses might be greater, but this would ordinarily be offset by the saving in cost of storage space. Greater handling loss from improper operation of handling equipment might result from negligence and could not properly be called an expected annual storage cost.

Conditioning

Conditioning may be profitable to the farmer in one of two ways. It may improve the grade and bring a higher price. Or by reducing the moisture content to a safe level for holding the soybeans, it may allow storage at harvest time, or may allow the storage period to be extended. The alternative to conditioning cost often will be lower market grade and a lower price when the soybeans are sold. This is true whether the cost is for turning, for drying or for fumigation.

Insect damage or control is not a problem in soybean storage under ordinary farm storage conditions in the Midwest. Insect damage usually accompanies heating or molding which is more likely to occur in high-moisture beans (13). Clean, dry beans stored in tight structures ordinarily incur no loss of grade from either cause.

Conditioning is not essential every year in storing soybeans on farms. Soybeans at 12-percent moisture content are safe for year-round storage; at 13 percent, for storage until warm weather. In most years the moisture content of soybeans at harvest falls within

[13] There are approximately 80 manufacturers of grain-handling equipment distributed throughout the soybean-producing States.

[14] Leo E. Holman, agricultural engineer, U. S. Department of Agriculture, personal communication.

safe storage limits; however, soybeans harvested during a cool, rainy season may require conditioning for safe storage. Conditioning holds promise for farmers who want to hold soybeans harvested at 13-percent moisture in storage through the warm spring months.

Conditioning farm-stored soybeans by turning them--transferring from one bin to another - ordinarily is unsatisfactory. First, this method either requires an empty bin, or else involves a fairly high loss if the beans are piled on the ground, then elevated back into the bin. Second, turning ordinarily does not lower the moisture content of beans significantly, although it helps equalize moisture content and control heating by mixing the warm beans with the cool.

Although few farmers are likely to invest much in conditioning equipment that is not to be used every year, many soybean growers in the Midwest may feel the investment justified for their corn or wheat crops. In the midwestern corn-soybean and wheat-soybean areas (fig. 4, page 8), which produce about 85 percent of the soybeans in the United States, this is particularly significant, with the increasing adoption of long-season, high-yielding varieties of hybrid corn, and harvesting machinery that puts both corn and wheat into storage with little opportunity for natural drying. Conditioning may be needed on a particular farm almost every year for either crop or both (10, 42). Corn harvested by the combined picker-sheller regularly requires conditioning for safe farm storage, and thus accentuates the need of driers.

Drying cost varies with the type of drying. A drying bin costs more per bushel of capacity than a storage bin. Fan drying with natural air depends on favorable weather, and offers advantages of lower investment in equipment, lower operating expenses, lower fire hazard, and lower labor requirement, particularly if a humidistat is installed to regulate the fan operation. Heated-air drying, on the other hand, takes less time.

The cost of conditioning grain on farms includes investment in conditioning equipment, operating expenses for power and labor, and the weight loss in drying and handling.

The total investment in conditioning equipment may range from the cost of a moisture tester, fan, humidistat, and perforated floor to that of an extra bin with perforated floor, heated-air drier with fan, and moisture tester. A 3-horsepower motor is adequate for on-farm fan drying of a wide range of crops and conditions; smaller motors may be adequate for use limited to a particular crop. Satisfactory results ordinarily can be obtained by following manufacturers' specifications and recommendations.

Typical retail costs for such equipment early in 1951 are $450 to $500 for a complete fan unit, including fan, 3-horsepower motor, base, starter, and drive, and $20 and up for a humidistat. The added cost of perforated floor over solid floor for metal storage bins varies with the diameter, ranging generally from $35 to $50. Heated-air driers for farm use range in cost from about $1000 to $1600. Moisture testers vary in cost; some electric models suitable for farm use are quoted at about $65. Inexpensive mineral salts may be used for estimating moisture content (11); kits using these salts are expected to be available commercially soon.[15] Metal bins with perforated floors range in price from $275 to $1000, depending on size.

Some manufacturers of crop-conditioning equipment offer a planning service, designed to assist farmers in the selection, installation, and operation of equipment, based on their individual requirements. Recommendations for corn drying in U.S.D.A. Circular 839 may be followed in drying soybeans; specifications for farm driers are also listed.

Experimental work and farm trials in mechanical crop conditioning have been largely concentrated on corn and hay. Because crop conditioning on farms is a recent development, there are few data on the useful life of drying equipment, and therefore on depreciation rates. Also, because of improvements in efficiency and fire-safety features, some of the earlier equipment may be obsolete or too expensive to operate, even though it is not worn out. It would appear sound practice for the present to depreciate such equipment as rapidly as allowed by Federal income tax regulations. A 10-year useful life is generally recommended for depreciation on drying equipment.

Operating expenses for conditioning vary with the power and fuel used. Although fan drying requires less power than heat drying, the amount varies widely, the effectiveness of the method varying directly with air temperature and inversely with relative humidity.

Heated-air drying involves greater fuel cost, and usually involves labor cost also, as most driers require constant attention. However, some of the larger farm-type driers are equipped with safety devices that turn off the heater in the event of mechanical failure or improper functioning. Some engineers have reported fuel cost around 1 cent per bushel for each 1 percent of moisture removed. In corn-drying tests at Chalmers, Ind., (14), fuel and labor cost ranged from 2 cents to 4 cents per bushel for 1-percent to 1.5-percent moisture removal.

The cost of the loss of weight in drying soybeans depends on the amount of moisture removed and the price of the soybeans. The weight lost in drying beans from a moisture content of 16 per cent to 12 per cent amounts

[15] S. T. Dexter, agronomist at Michigan State College, personal communication.

to 4.5 per cent of the original weight. At $3 per bushel, this weight loss amounts to 13.5 cents per bushel. This is not the cost to farmers; country elevators commonly price damp soybeans 3 to 5 cents lower. Subtracting this discount results in an actual cost of 8.5 to 10.5 cents per bushel for the weight lost. Total drying cost would include also shrinkage from the additional handling[16] along with equipment and power cost.

It would pay farmers to dry soybeans under those price and moisture conditions in order to extend the storage period, provided the farmers then received an additional 20 cents or more per bushel. Drying soybeans in order to store them obviously would increase a farmer's net returns once the soybean price had increased more than enough to cover all costs involved. However, drying soybeans at the time of sale, for price improvement based on better grade, would not pay under ordinary country elevator pricing practice, as the customary price differential would not cover drying cost.

Total Storage Cost

Total cost for storing soybeans on farms may be expected to vary from one farm to another, because of the wide range in amount of individual cost items. Investment costs vary because of differences in the initial cost of the storage building, its expected useful life, its insurance or risk, and taxes on its value. Operating expenses vary widely, particularly the costs related to the value of the soybeans. Interest (or credit) and insurance costs are variable within a certain range according to individual farmer choice. Property taxes on the soybeans, however, vary from one State to another and between taxing units within a particular State, with differences in tax law and assessment practice, and with the time of assessment, because market value on the various assessment dates may be seasonally low or at the spring-summer peak levels.

Typical total storage costs are shown in table 3. Three months' storage totals about 7.8, 9.3, and 10.3 cents per bushel for typical round metal bins, frame granaries, and corn-crib-granaries, respectively. Six months' storage totals about 9.6, 11.2, and 12.2 cents, respectively. For comparison, typical costs to farmers for soybean storage at country elevators (6.5 cents for 3 months, 12.6 cents for 6 months) are also shown (19, 40). Figure 6 shows variations in storage costs associated with different harvest prices, types of storage, and lengths of storage periods. Farm storage costs shown in table 3 and figure 6 are based on use at 100-percent capacity. In keeping their accounts, some farmers may double the charge for storage space, per bushel of grain stored, when only half of the storage space is being used, because the total building cost is independent of the amount of grain stored. Thus, for 50-percent use, total cost would include higher space cost; for 6 months, space cost would be 4.4, 7.2, and 9.2 cents per bushel, and total storage cost 11.8, 14.8 and 16.8 cents, using storage structures with an initial cost of 40, 60, and 90 cents, respectively, per bushel of capacity. However, some State agricultural experiment stations recommend that the building cost be charged to the crop rather than to storage (39).

Conditioning cost is not included in table 3 or figures 1, 2, and 6, because the moisture content of soybeans at harvest is ordinarily within the required moisture limits for storage. However, a farmer who wishes to store his soybeans may find their moisture content too high; or prolonged unfavorable weather at harvest may result in high-moisture soybeans over a wide area. These farmers have only three alternatives. They may sell at harvest, or store until the beans begin to go out of condition; either may mean selling at depressed prices. They may store the beans and take the chance of selling out of storage at substantial price discounts for loss of grade. Or, by conditioning the soybeans, they may store for price improvement and be able to sell when they choose.

HOW QUALITY CHANGES IN STORAGE AFFECT SOYBEAN MARKETING

To take advantage of seasonal price advances and assure profitable storage of his soybeans, a farmer must maintain their quality. Deterioration of his soybeans during the early part of the marketing season may make it necessary for the farmer to sell regardless of price.

Furthermore, a decrease in soybean quality increases the cost of storage. If the farmer's soybeans start to deteriorate in storage, extra labor is necessary to turn them. Excess moisture contributes to the deterioration of soybeans by providing the conditions for the development of other deteriorating factors. The results are lower quality and reduced profits. If moisture enters through cracks, joints, or seams in the storage structure, the soybeans must be dried at considerable expense; otherwise molds, insects, and heating will develop with a resulting reduction in market grade and decreased drying ability and impaired flavor of the oil (45). In addition, free fatty acids develop in the oil, reducing its commercial value.

In wooden structures, any pockets of heating soybeans near the cracks or joints in the walls

[16] One-quarter of 1 per cent if the beans are dried for storage and are moved directly from the drier to storage; 0.5 per cent if they must be handled twice or moved from the storage bin to the drier and back again, which would cost 0.75 to 1.5 cents with soybeans priced at $3 per bushel.

Table 3.--Typical cost to farmers for soybean storage on farms and at country elevators, for 3-month and 6-month storage periods, midwestern soybean-producing States[1]

Cost elements	Cost per bushel							
	3-month storage				6-month storage			
	Farm storage building: type and initial cost[2]			At country elevators	Farm storage building: type and initial cost[2]			At country elevators
	A $0.40	B $0.60	C $0.90		A $0.40	B $0.60	C $0.90	
	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
Fixed costs:[3]								
Storage Space[4]	2.2	3.6	4.6	[5]*4.5	2.2	3.6	4.6	[5]*9.0
Depreciation and Interest[6]	(2.1)	(3.2)	(4.0)	---	(2.1)	(3.2)	(4.0)	---
Insurance[7]	(.09)	(.3)	(.5)	---	(.09)	(.3)	(.5)	---
Property taxes[8]	(.04)	(.06)	(.1)	---	(.04)	(.06)	(.1)	---
In-and-out handling[9]	*1.3	*1.3	*1.3	---	*1.3	*1.3	*1.3	---
Total fixed cost	3.5	4.9	5.9	*4.5	3.5	4.9	5.9	*9.0
Variable costs:[10]								
Shrinkage[11]	1.5	1.5	1.5	---	1.5	1.5	1.5	---
Interest on value[12]	2.5	2.5	2.5	2.0	4.1	4.1	4.1	3.6
Insurance or risk[13]	.3	.4	.4	([5])	.5	.7	.7	([5])
Property taxes (on soybeans)[14]	---	---	---	---	---	---	---	---
Total variable cost	*4.3	*4.4	*4.4	*2.0	*6.1	*6.3	*6.3	*3.6
Total storage cost	7.8	9.3	10.3	6.5	9.6	11.2	12.2	12.6
Prime cost[15]	5.6	5.7	5.7	6.5	7.4	7.6	7.6	12.6

[1]Ohio, Indiana, Illinois, Missouri, Iowa, Minnesota. These States account for about 90 percent of the soybeans harvested.

[2]Farm storage building types: A, metal single bin; B, frame multiple bin, capacities roughly comparable to those of type A; C, frame combination corncrib-granary. Initial cost for all types is total cost, constructed, per bushel of grain storage capacity.

[3]Costs that are determined, for a given lot of soybeans, by factors other than the value or condition of the beans.

[4]The sum of depreciation, interest, insurance, and property taxes, per bushel of capacity. From a strict cost-accounting standpoint, space cost varies inversely with the proportion of space actually used. However, space cost is actually a "sunk" cost, as its cost must be borne by the farm business whether the storage building is used or not.

[5]Elevator storages charge 1.5 cents per bushel, per month; including insurance on the beans Some elevators charge the full season rate for shorter storage periods.

[6]Return of the investment, based on estimated useful life of 30 years for building types A and B, of 40 years for building type C, plus earnings on undepreciated value at 4 percent interest on average value (one-half the initial investment).

[7]Buildings insured for average value, building type A against windstorm only, building types B and C against fire, lightning, and wind.

[8]Assuming 100 percent assessment at average value, and tax rate averaging 2 percent. In practice, actual assessment rates are likely to be lower and tax rates moderately higher.

[9]Power and labor cost on farms; some elevators charge for handling when the grain is stored on farmer account.

[10]Costs which vary with the price of soybeans. Soybean price, $3.00 per bushel.

[11]Negligible weight loss from drying out in storage. Allowance for 0.5 percent total loss in handling in and out of farm storage.

[12]Interest at 3 percent per year at support-price level of $2.06, plus service fee at 1 cent per bushel on farms, 0.5 cent per bushel at elevators.

[13]Insured value $1.50 per bushel (50 percent of market value). Beans stored in metal bins insured against windstorm loss only; in frame buildings, against fire, lightning, and windstorm.

[14]Property taxes become a cost of storing soybeans on farms on January 1 in Missouri and Ohio, March 1 in Indiana, March 10 in Nebraska, April 1 in Illinois and Michigan, May 1 in Minnesota and South Dakota, July 1 in Kentucky, July 31 in Arkansas. For estimates of the amount of property tax cost, refer to Table 13, p. 47, Cash Costs of Farm Storage in Marketing Soybeans, U.S.D.A., P.& M.A., Sept. 1950. In some States where property tax is a storage cost for farmer-owned beans, the amount is the same for on-farm or off-farm storage; in others, cost may favor farm storage through exemption of the farm-stored beans or through lower required assessment rates.

[15]Out-of-pocket cost to farmers for soybean storage, including all the asterisked (*) cost elements.

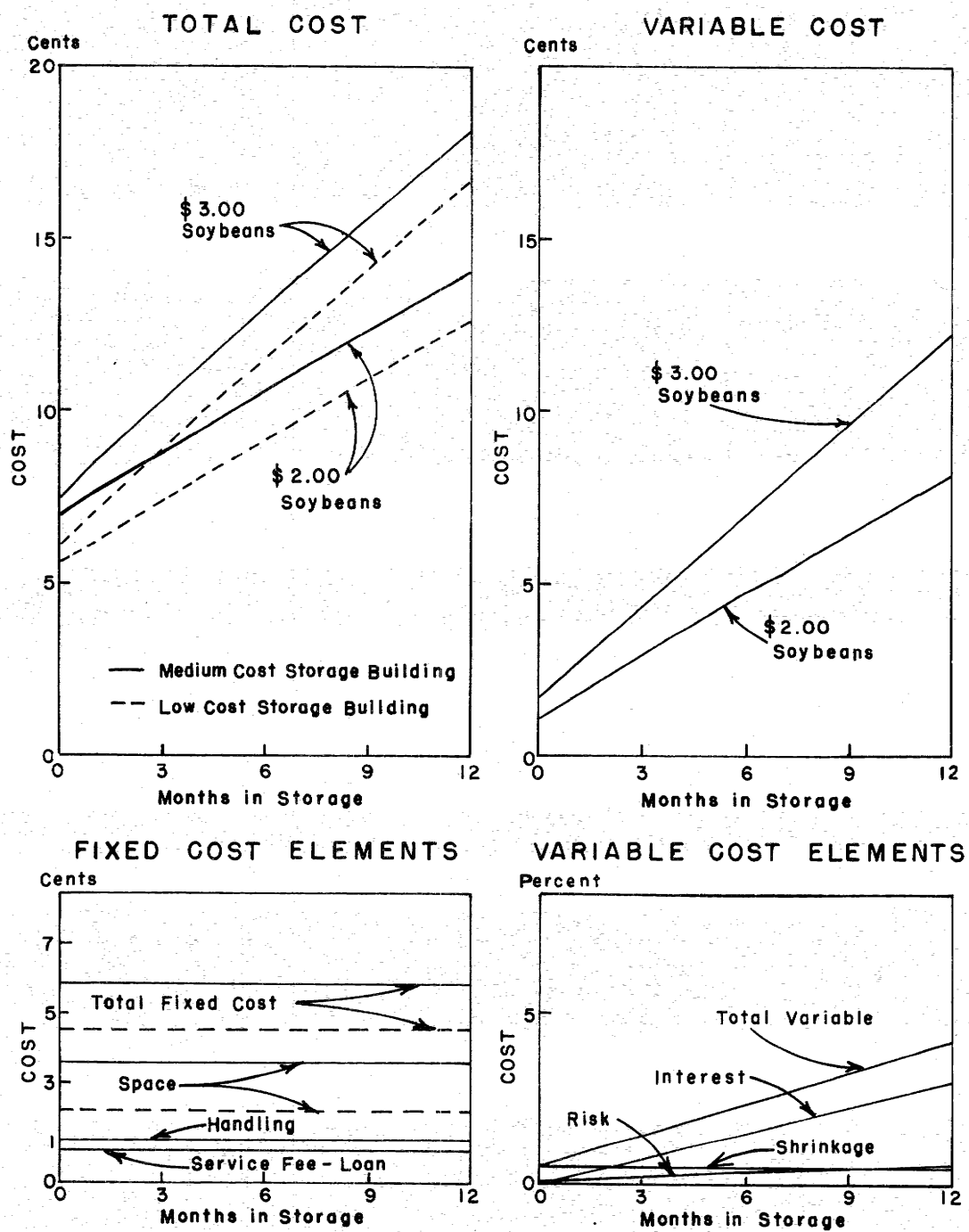

Figure 6--Cost range for storing soybeans on farms. In comparing soybean storage cost from one farm to another, or between farms and elevators, it is important to distinguish between cost elements which are independent of soybean prices, and those which vary with price. Equally important is the distinction between costs which are incurred only once and those which increase with the length of storage.

shorten the life of the building material in those spots. With high moisture and temperature, the possibility of insect infestation becomes greater, making fumigation necessary. Any physical loss of soybeans from imperfect bins or through handling increases the cost of storing the farmer's crop.

Changes in quality for any of the foregoing reasons put farmers at a disadvantage with respect to insurance, tax, and credit costs, and may even prevent storage of some soybeans. Taxes and insurance will be charged at the same rate on soybeans that have deteriorated as on good quality soybeans, although the market value is reduced.

Soybeans that are harvested with a high moisture content or that contain excessive amounts of splits or damaged beans are not satisfactory collateral for a loan. Also they will deteriorate more in storage, so that more expensive control measures are required. Some farmers thus unable to obtain loans on their soybeans will be unable to store, but must sell them at harvest time.

Factors Causing Quality Changes

Soybeans in storage are subject to deterioration from an excessively high moisture content and from molds, insect infestation, and heating. Those damaged by unfavorable weather and improper harvesting are more easily affected by these factors.

Moisture

High moisture content is the most frequent cause of deterioration of soybeans either in or out of storage Studies conducted at the University of Illinois showed a tendency for air moving through a bin of soybeans to pick up moisture and deposit it near the top center of the bin. Soybeans having a moisture content of 12 percent or less when stored were later found to have increased to from 15 to 19 percent in moisture near the top center of the bin. This was more pronounced in steel bins than in wood bins (7).

During the fall and early winter, the air in the soybean bin moved down the cool walls and rose through the center, transferring moisture from the rest of the bin to the rounded top of the pile from 1 to 2 feet deep at the center and shallower toward the walls. In general, the accumulation of moisture from the air movements does not affect any large volume of soybeans unless the average moisture content for the bins is 13 percent or higher (22). In short, soybeans with 12-percent moisture in good storage are not in danger of serious deterioration but the moisture content can not be allowed to increase much above that level without endangering the profit of the storage enterprise.

When exposed to humid air soybeans absorb moisture readily, the extent depending on the relative humidity of the air, as shown in figure 7. Points on the curve indicate the amount of moisture soybeans tend to contain at various relative humidities. In general, it takes soybeans about 2 weeks to reach a moisture equilibrium with the atmosphere (26).

Molds

Soybeans stored too damp can provide ideal conditions for mold growth. Mold spores are always present in the stored soybeans but develop only when they have the right combination of temperature and moisture (48). Broken seed coats then permit the molds to feed on the soybeans. Harvested soybeans containing 20 percent splits are not uncommon, and, of course, there are many broken seed coats as well.

A high content of free fatty acids[17] in soybeans is usually the result of the action of molds, the enzymes of which cause a decomposition of the soybean oil with a liberation of free fatty acids (23, 33, 54). The free fatty acid content is a good indicator of soybean deterioration because it increases more rapidly in the early stages of fat deterioration than does protein or carbohydrate decomposition (54). Once the soybean has been physically damaged, the liberation of free fatty acids is increased. Also, seeds which have been bruised or crushed develop free fatty acids faster than those which have been cut or broken cleanly (2). At moisture levels where molds grow, the percentage of free fatty acids increases drastically in soybeans that are severely damaged by frost (31, 34). The relationship between the moisture content of certain lots of soybeans and the acid number[18] of the oil is shown in figure 8. Molds were observed on frost-damaged soybeans having moisture contents exceeding 15 percent. Good quality soybeans showed very little increase in free fatty acid content during this experiment.

Certain molds are particularly harmful to soybeans stored for seeding purposes. The ability of soybeans to germinate is affected by one particular form of mold (Aspergillus), which infects many of the seeds that have a moisture content of 13 percent or more and are at room temperature or higher. In high-moisture samples, the number of seeds infected with Aspergillus has been found to increase when the storage temperature increases,

[17] Soybean oil on decomposition breaks down into free fatty acids and glycerin. This decomposition reduces the commercial value of the oil.

[18] The acid number is a measure of the quantity of free fatty acids in the oil and is determined by finding the number of milligrams of potassium hydroxide required to neutralize the free fatty acids in one gram of oil.

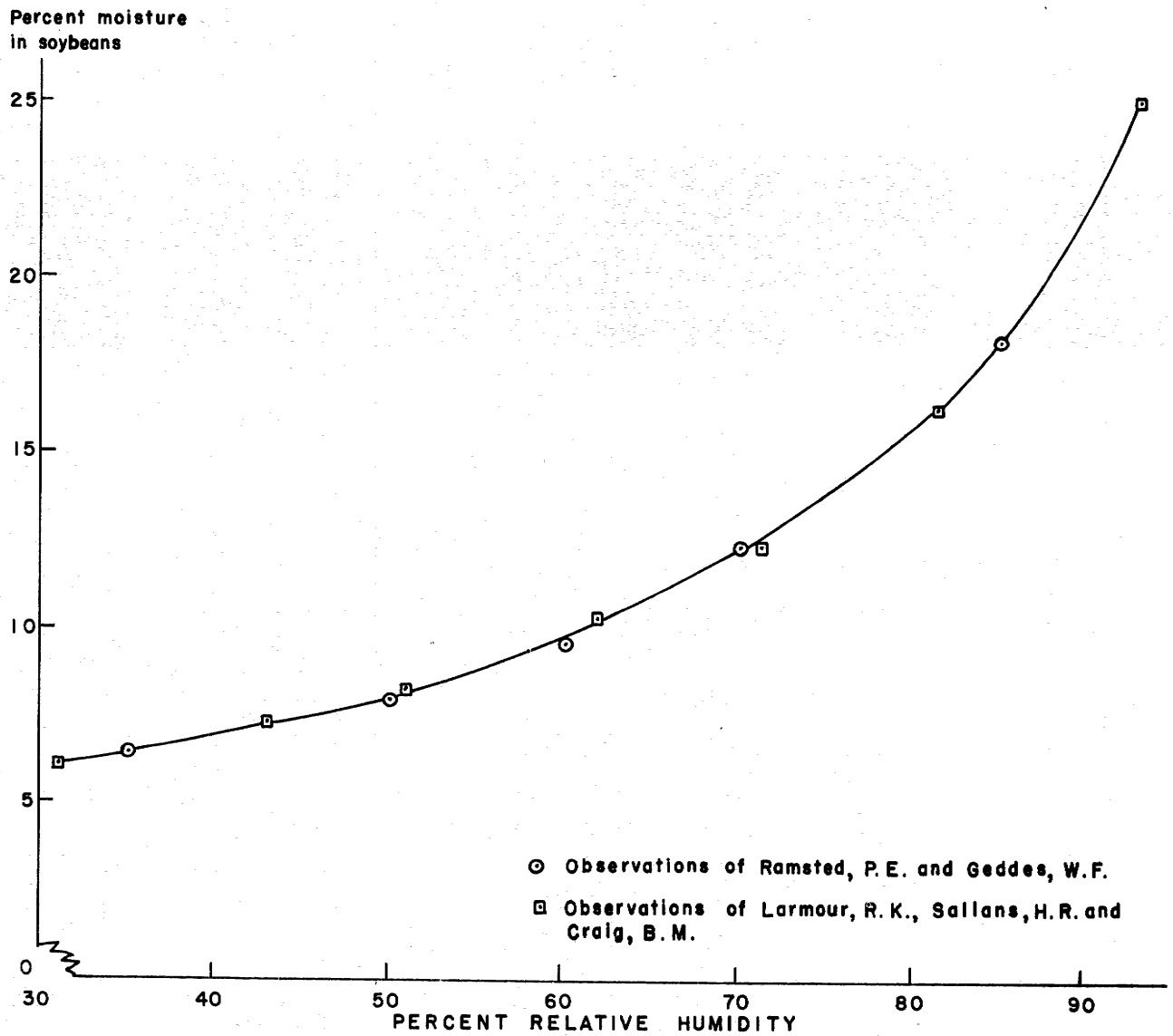

Figure 7--Percentage moisture in stored soybeans in relation to atmospheric humidity, after reaching the point of equilibrium. Compiled from Minn. Tech. Bul. No. 156, 1942 (p. 10) and Canadian Journal of Research, Sec. F, 1944 (p. 5).

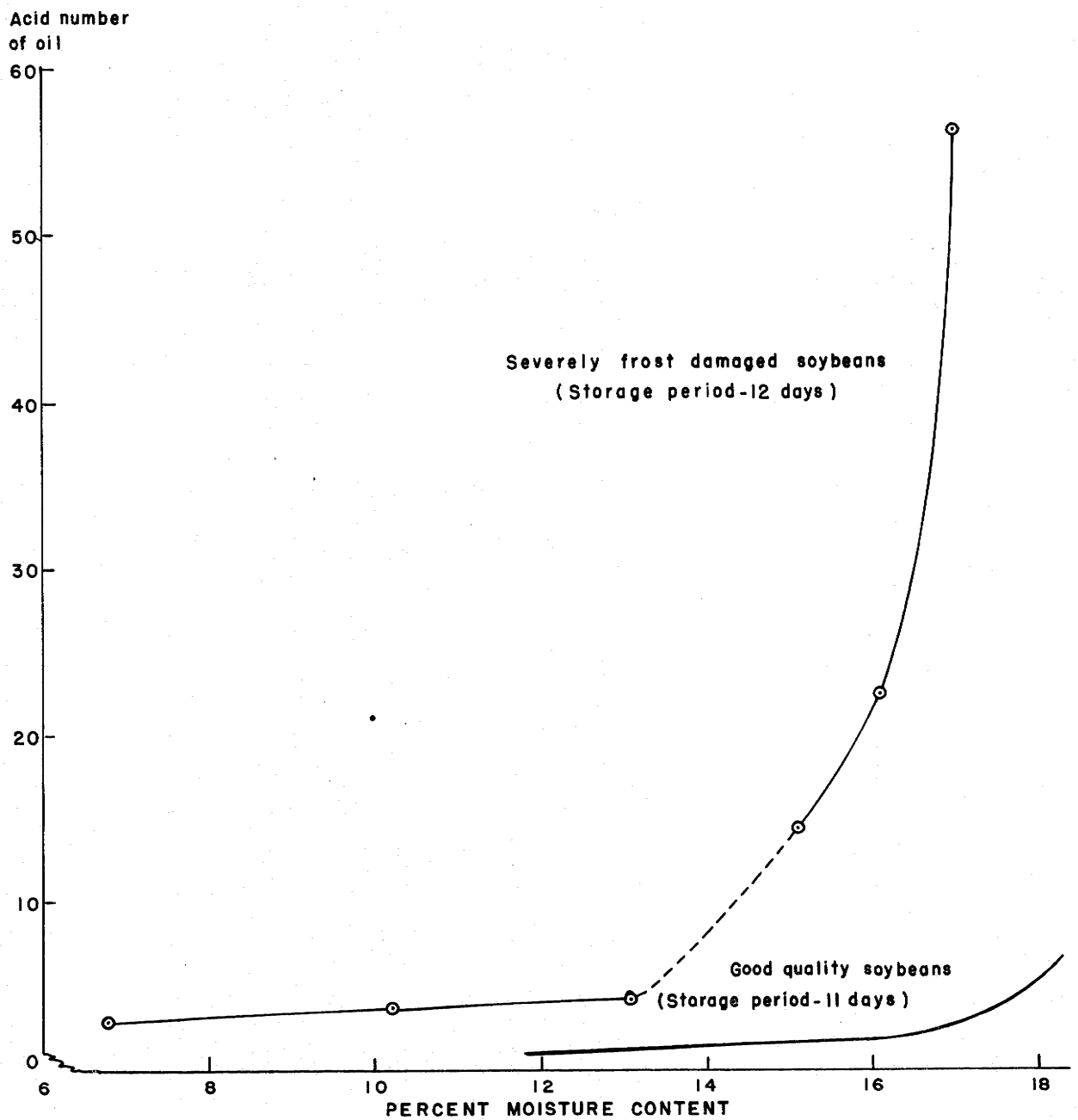

Figure 8--Relation of moisture content of stored soybeans to acid number of oil as influenced by soybean quality. The soybeans were held at temperature of 100°F. and aerated at rate of 2000 ml. per day. Compiled from Cereal Chemistry, May, 1946 (pp. 231, 233).

reaching a maximum at approximately 113°F Apparently, the molds, especially Aspergillus, are also responsible for much of the heating (51).

Insects

It appears that most grain-infesting insects do not damage hard, dry soybeans. Insects that are attracted to decaying material may damage soybeans at moisture contents above 14 percent. Spots of decaying soybeans form under roof leaks, or along the walls where moisture has entered. Even a bin filled with 12-percent moisture soybeans may have spots of higher moisture content, which set up conditions favorable to insect growth (13).

Heating

Heating of stored soybeans is the result of the respiration[19] of the beans and of bacteria, molds, and insects. Heating is more rapid the higher the moisture content of the soybeans. In one test the temperature of a bin of soybeans stored at 18.8-percent moisture rose from 79° to 126°F. in 14 days. (43).

The "respiration rate" was six times faster for split soybeans than for whole soybeans stored for four weeks at an initial moisture content of 15.8 percent (43).

At the same moisture content, cracked, shriveled, and immature kernels respire at a more rapid rate than sound, plump grain. Respiration increases when foreign material, and sprouted and frost- or heat-damaged kernels are mixed in with the grain (16). There is evidence that the storage behavior of soybeans is quite similar.

The farmer who wants to produce good soybeans for seeding needs to consider the effects of storage conditions on the ability of soybeans to sprout. Results from 8,700 growers in Illinois, Indiana, and Ohio showed that high-germinating seed planted in a well-prepared seed bed increased yield on the average of 2 bushels per acre (35). Work at the Minnesota Agricultural Experiment Station indicated that poor stands of soybeans or stunted, slow-growing plants sometimes resulted from mold damage to the soybeans in storage (50). Heat damage, too, will reduce the germination of soybeans. The ability of soybeans to sprout decreases as the moisture content of the stored soybeans increases (15, 43). The viability and vigor of soybeans decreases rapidly when moisture content exceeds 13 percent (51).

That very satisfactory germination can be obtained from soybeans after storage at the proper moisture content is indicated by an experiment conducted by the Illinois Agricultural Experiment Station. Soybeans with a moisture content of 11.1 percent were placed in storage in October. The following May, when they would normally have been planted, the soybeans on the surface germinated 92 percent, those lying a foot below the surface germinated 97 percent, and those from greater depths germinated 100 percent (5). Further evidence exists that the ability of soybeans to sprout can be maintained. One lot of soybeans tested by the United States Department of Agriculture had a moisture content of 8 to 9 percent and was held at a temperature of 35°F. for 8 years without suffering a loss in viability. Another lot with 13 to 14 percent moisture held at 70°F. showed no germination after 20 months in storage (52).

ECONOMIC EFFECTS OF QUALITY CHANGES

The necessity for good storage can hardly be overestimated. Frequently soybeans are damaged in the field. These beans will deteriorate more rapidly in storage than will sound ones. In either case, good storage is an economic advantage because deterioration means lower return to the grower, increased cost of processing, and smaller or poorer-quality outturn of products. These results occur, to a lesser extent, even when deterioration is too small to be recognized as a reduction in grade.

Farmer's Marketing Schedules

If a farmer's soybeans start to deteriorate badly in storage, he may be forced to sell them when prices happen to be low. For example, if farmers in Illinois had been forced to sell their 1949 crop out of storage in December, January, or February, most of them would have lost money (figure 2, 1949 crop). Most of the farmers able to sell their soybeans out of storage after these months would have increased their profits. If a farmer plans to store soybeans and wants to control the time of sale, he must put good quality soybeans in storage structures that are in good condition.

Shrinkage

Shrinkage in the total weight of a lot of soybeans is a result of their falling out of

[19] A seed contains living material, and the maintenance of this life requires the utilization of the food contained in the seed (30). In order to use this nutrient material, oxygen must be taken from the air and carbon dioxide, water, and heat must be released. This process is known as respiration in grain.

At relative humidities below that critical for mold growth the respiration of grain is almost entirely due to the seeds themselves. When the relative humidities rise above the critical point (75 percent) the molds are responsible for most of the respiration (30). Molds produce large amounts of carbon dioxide and heat (30, 32, 17). They will produce and tolerate temperatures up to 130 F. (30).

handling equipment, of cracks in the bin, or of a reduction in weight because of moisture loss or heating. Some farmers suffer severe losses from leakage of soybeans from storage bins. Estimates on loss from leaky bins run as high as 10 to 15 percent in a 6-month storage period (29). Profit from storage cannot be expected to exceed any such loss over a period of years.

Tests to determine moisture loss of soybeans stored under farm conditions were made at the Illinois Agricultural Experiment Station. Soybeans with 11.1 percent moisture placed in a portable crib in October had the greatest loss of weight during December (0.6 percent) and the greatest gain during the following April (0.8 percent). The weight of the soybeans while in storage varied directly with the relative humidity and inversely with temperature (5).

Seventy-six thousand bushels of soybeans used in a storage study at the University of Illinois during the period of October 1943 to November 1947 showed a quantity loss of but 0.3 percent during this period. Many of the soybeans were transferred between bins and others were dried during this time.[20] These experiments showed also that the entrance of moisture into the bins was partly due to poor materials or shrinkage of siding on prefabricated bins (8).

Grade

Reduction of a full grade can result from a lowering of any one grade factor of soybeans below the specified grade limitations (table 4). Therefore, to protect his storage venture a farmer needs to consider each factor by itself, even though he may largely control them jointly. By adopting better harvesting (3) and storage practices he can control them all - moisture, test weight per bushel, percentage of splits, damage[21], and foreign material. These individual grade factors are important because they affect the use that will be made of the soybeans and the quality and quantity of the resulting products.

Damage of various kinds begins in the field, usually as a result of unfavorable weather conditions. Many soybeans split in the field as a result of the harvesting operation or when being loaded into a storage bin. Foreign material mixes with the beans during the harvesting operation. Field- and frost-damaged soybeans and split soybeans are difficult to store. Also, the presence of foreign material, especially green weed seeds, increases the difficulty of storing soybeans.

Excessive moisture frequently leads to heating, but it may cause difficulties without any noticeable heating. Growth of mold too light to cause heating may be enough to give a musty odor (23). Soybeans that are musty, sour, heating, or have a commercially objectionable foreign odor are graded Sample grade. In one experiment, soybeans with 12 percent moisture stored 2-1/3 years showed very little change in grade, but several bins with 13 to 14 percent moisture stored from January to October graded Sample grade because of a musty odor. In this experiment all soybeans stored with more than 14 percent moisture during this same period graded Sample grade (22).

There are also disadvantages to having moisture content too low. Binning and reloading soybeans with a moisture content ranging from 8 to 9 percent have frequently resulted in splitting and mechanically damaging them so that they were lowered one or more market grades.

Splits and damage percentage of soybeans, as well as moisture content, are grade factors that affect the formation of free fatty acids. When refining soybean oil, the amount of refined oil obtained is less than the initial amount of crude oil, and a part of this refining loss [22] is composed of free fatty acids.[23] In one study, commercial soybeans stored with moisture contents ranging from 13.5 to 13.7 percent contained nearly twice as much free fatty acids as soybeans stored with moisture contents ranging from 12.2 to 12.5 percent. The storage period in both cases was from January to August (8). In another study, it was found that damaged soybeans ordinarily contained a higher percentage of free fatty acids than did sound soybeans (25). Analysis of those factors affecting the quality and quantity of soybean products by the Fats and Oils Branch, Production and Marketing Administration, shows the free fatty acid content of severely damaged soybeans to be noticeably higher than that found in sound soybeans.

The oil in split soybeans oxidizes and causes an increase in refining loss. Processors, therefore, do not leave soybeans with a high

[20] Leo Holman, agricultural engineer, U. S. Department of Agriculture, official correspondence.

[21] The types of damage to soybeans--heat, frost, field, weather, mold, disease, green, and rot--vary in their effect upon the quantity and quality of oil derived from the beans.

[22] The National Soybean Processors Association Trading Rules governing price settlements of crude soybean oil establishes 7 percent as the basic refining loss for contract prices. The seller then gets a premium or suffers a discount of 3/4 of 1 percent of the contract price for each 1 percent refining loss below or above the basic 7 percent (36).

[23] Soybeans have been known to deteriorate during storage to the extent that free fatty acid content increased to 1.8 percent with a refining loss of 11.0 percent.

Table 4.--Official U. S. grades and grade requirements for all classes of soybeans

Grade	Minimum test weight per bu.	Maximum limits of -			
		Moisture	Splits	Damaged kernels (soybean and other grains)	Foreign material
	Pounds	Percent	Percent	Percent	Percent
No. 1[1]	56	13.0	10.0	2.0	2.0
No. 2[1]	54	14.0	20.0	3.0	3.0
No. 3[1]	52	16.0	30.0	5.0	4.0
No. 4[2]	49	18.0	40.0	8.0	6.0
Sample grade	Sample grade shall be soybeans which do not meet the requirements for any of the grades from No. 1 to No. 4, inclusive; or which are musty or sour, or heating; or which have any commercially objectionable foreign odor; or which contain stones; or which are otherwise of distinctly low quality.				

[1]The soybeans in grade No. 1 of the class Yellow Soybeans may contain not more than 1.0 percent, in grade No. 2 not more than 2.0 percent, and in grade No. 3 not more than 5.0 percent of Green, Black, Brown, or bicolored soybeans, either singly or in any combination.
[2]Soybeans which are materially weathered shall not be graded higher than No. 4.

Source: From Handbook of Official Grain Standards of the United States, 1950, page 72, United States Department of Agriculture.

split content in storage for a long time but process them as soon as possible.

Green damage causes little trouble in the extraction of oil, but the process of removing the green color from the oil increases the cost of refining (9).

Matured soybeans that are exposed to rains and damp weather for a long time in the field develop a dark-brown color and a mealy or chalky texture. Such soybeans tend to sprout and decay in the pod. These field-damaged soybeans wear out processing equipment very rapidly. Although they usually contain as much oil as sound soybeans, less oil can be recovered in the processing operation (9).

The quantity of soybean oil utilized in the drying oil field has increased greatly since World War II. Most of this oil is used to manufacture alkyd varnishes for use in enamels and paints (27). The total use of soybean oil in drying products during the first nine months of 1950 was 143 million pounds (53). This is the oil equivalent of 14 million bushels of soybeans. High moisture content and its accompanying effects in stored soybeans will tend to lower the drying ability of the oil (figure 9). When 32 samples were analyzed at the U. S. Regional Soybean Laboratory, the iodine number[24] of the oil from damaged soybeans ranged from 13.5 below to 1.7 above that for sound soybeans (25).

It is difficult to manufacture uniform industrial protein products (adhesives for plywood, foam solutions, paper coatings, paper sizing, and emulsion paints) from immature soybeans and those showing frost or field damage. Fully matured No. 1 and No. 2 yellow soybeans of normal moisture content give the least trouble when manufacturing these products (47).

In fact, quality so greatly affects the value of soybeans for most uses that the farmer should keep the quality as high as possible whether or not he intends to store them. Foreign buyers (38) of United States soybeans are reported to have complained of their quality, particularly with regard to the foreign material content (37, 49).

Country elevator operators do not as a rule grade the farmer's soybeans.[25] The buyers do consider the individual grade factors when arriving at the price that they will pay the farmer. For example, a farmer must usually

[24]Drying ability or the capacity of an oil to absorb oxygen is measured by its iodine number. The iodine number is the number of grams of iodine absorbed by 100 grams of oil.

[25]Those elevator operators that do assign grades pay from 1 to 4 cents per bushel higher for soybeans grading No. 2 than for those grading No. 3.

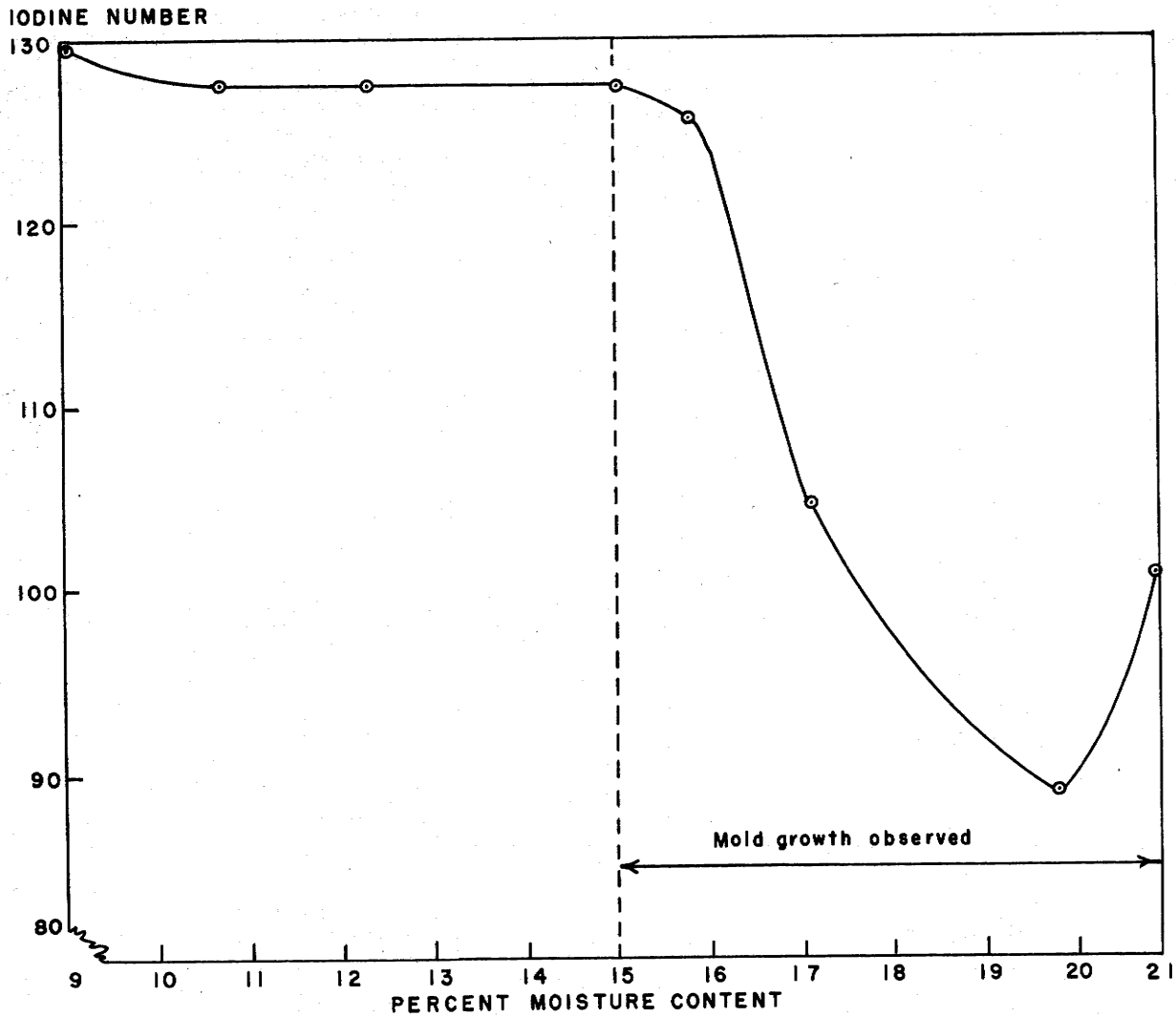

Figure 9--Iodine number of oil in soybeans of various moisture contents stored at room temperatures for one year. Compiled from Minn. Tech. Bul. No. 156, 1942 (p. 27).

accept a price discount if his soybeans are high in moisture content or show a low test weight per bushel.

At some country elevators, discounts are based on only those grade factors that the elevator operator has the time to measure. Furthermore, the operator may not sample every load. For example, if a farmer plans to haul soybeans to an elevator all during a rush day, the elevator operator may determine the moisture content of one load only. Then all loads for the day will be judged by that single load.

Other elevator operators may determine the test weight per bushel along with moisture. Too many splits and damaged soybeans or too much foreign material will result in a discount in price. Country elevator operators, through long years of experience, have learned to estimate the various grade factors. By scooping up handfuls of soybeans, they get an idea of the moisture content, percentages of split and damaged soybeans, foreign material content and test weight per bushel. The number of grade factors measured and the discounts applicable to each depend upon the pricing practice followed by the individual elevator operator.

The condition of the soybeans determines the actual price the producer receives on the market as well as his freedom to pick the time when he will sell. The farmer can do a great deal in the way of controlling deterioration of soybeans in storage by adopting good harvesting, handling, and storage practices. Moisture content can be controlled by harvesting at the proper time, storing in a tight bin, and, if need be, by conditioning with forced natural or artificially dried air (4, 20, 28). Natural ventilation (drying with air that is not forced) is not effective (6). On an experimental basis, the mixing of wooden blocks with soybeans has indicated a possibility of removing moisture from small lots (12). These controls do involve cost, however, and they, together with the other costs of storage, must be less than the expected rise in soybean price if storage is to be of benefit in the farmer's marketing program.

The idea that it would pay all soybean producers to store all of their soybean crop is no more trustworthy than the idea that the whole crop should be sold at harvest time. Farm storage of soybeans will pay under favorable circumstances and with wise harvesting and storage practices. Consequently many farmers willing to expend effort in adopting good practices and in careful management of their storage enterprise can earn extra profits from the more orderly marketing schedule.

METHOD OF STUDY

This report is based on a study of soybean storage conducted under the authority of the Research and Marketing Act of 1946. It brings together and analyzes from a marketing point of view data and other information previously available only in widely scattered sources, together with current data. The analysis made of storage practices, methods, buildings and equipment emphasized those found to be most efficient, convenient, and least costly, in order to establish practical and reasonably attainable goals for individual farmers' storage costs and practices.

Many data were obtained from agronomists, plant scientists, bacteriologists, entomologists, agricultural engineers, and agricultural chemists at various agricultural experiment stations, State agricultural colleges, the U. S. Soybean Laboratory at Urbana, Illinois, the Northern Regional Research Laboratory at Peoria, Illinois, and the U. S. Department of Agriculture Research Center at Beltsville, Maryland. Additional limited information was furnished informally by soybean growers, elevator operators and grain dealers, crushers, and oilseed product manufacturers. Important cost data were developed through an analysis of price lists and published and unpublished research results of various manufacturers and retail dealers handling farm buildings, machinery and equipment, or building supplies. Supplementary data were obtained through literature search, including all available soybean research reports published since 1930.

LITERATURE CITED

(1) Agnew, D. B. and Keirstead, C. H.
1950. Cash Costs of Farm Storage in Marketing Soybeans. U. S. Dept. Agriculture, Production and Marketing Administration, 62 pp., illus. (Processed.)

(2) Bailey, Alton E.
1945. Storage and Handling of Oil-Bearing Materials. Industrial Oil and Fat Products, Interscience Publishers, Inc. pp. 442-446. New York.

(3) Barger, E. L., and Weber, C. B.
1949. Harvest Losses in Soybeans, Iowa Farm Science, Iowa State College, 3 (12) : 8-10.

(4) Barre, H. J.
1948. Drying and Storing Soybeans on the Farm. Soybean Digest, 8 (10) : 14, 15.

(5) Burlison, W. L., Van Doren, C. A., and Hackleman, J. C.
1940. Eleven Years of Soybean Investigations. Illinois Agr. Expt. Station, Bul. 462, pp. 123-167, illus.

(6) Carter, Deane G.
1943. Grain Storage Studies. Agr. Engineering, 24 (8) : 270.

(7) ----------, and Holman, Leo
1944. Soybean Storage Studies. Soybean Digest, 4 (11) : 35, 64.
(8) ----------
1947. Storing Soybeans on the Farm. Papers presented at Soybean Processors Conference, University of Illinois, pp. 17-20. (Processed.)
(9) Cartter, J. L.
1947. Save Weather-Damaged Soybeans. U. S. Dept. Agriculture, Als-65, 9 pp.
(10) Dachtler, W. C.
1950. Grain Drying is Indispensable. Marketing Activities, U. S. Dept. Agriculture, Production and Marketing Administration, 13 (11) : 3-6.
(11) Dexter, S. T.
1948. Colorimetric Test for Estimating Moisture Content for Storing Farm Products. Mich. Agriculture Expt. Station Quarterly Bul., 30 (4) : 422-26.
(12) ----------, and Greighton, J. W.
1948. A Method for Curing Farm Products by the Use of Drying Agents. Journal Amer. Soc. Agronomy, 40 (1) : 71, 72.
(13) Farrar, M. D.
1944. Insects Attacking Soybeans Stored in Illinois. Soybean Digest, 4 (11) :32, 65.
(14) Foster, G. H.
1950. Drying Methods for Conditioning CCC-Owned Grain. U. S. Dept. Agr., Production and Marketing Administration, and Agr. Research Adm., in cooperation with Purdue Univ. Agr. Expt. Station, March. 10 pp.
(15) Fuelleman, R. F., and Burlison, W. L.
1944. The Germination of Stored Soybeans. Soybean Digest, 4 (11) : 30.
(16) Geddes, W. F.
1943. Factors Affecting the Keeping Qualities of Grain. Grain and Feed Journals, 90 : 501, 503.
(17) Gilman, Joseph C. and Semeniuk, G.
1948. Mold Microflora in Stored Grain and Its Role in the Deterioration Process. Amer. Assoc. Cereal Chemists Transactions, 6 (2) : 108-111.
(18) Gross, E. R., Walkden, H. H.
1948. Storing Grain in Small Bins. Marketing Activities, U. S. Dept. Agr., Production and Marketing Administration 11 (2) : 10-12.
(19) Hall, T. E., Larsen, A. L., Whitney, H. S., and Meyer, C. H.
1950. Where and How Much Cash Grain Storage for Oklahoma Farmers. U. S. Dept. Agr., Farm Credit Adm. Bul. No. 58, 48 pp., illus.
(20) Holman, Leo E.
1948. Soybean Storage and Conditioning. Paper presented at Crop Conditioning Equipment Conference, Washington, D.C., Beltsville, Md., May 17-18, 5 pp.
(21) ----------
1950. What is Good Soybean Storage? Paper presented at 30th Annual Convention, Amer. Soybean Assoc., Published in Soybean Digest, 10 (11) : 44-45.
(22) ----------, and Carter, Deane G.
1949. Farm Storage of Soybeans. Soybean Digest, 9 (10) : 14-16.
(23) Johnson, A. G.
1947. The Role of Fungi in the Deterioration of Grains in Storage. Preservation of Grains in Storage. Food and Agr. Organization, United Nations, pp. 88-91.
(24) Jordan, G. L.
1950. What Determines Soybean Prices? Paper presented at 30th Annual Convention, Amer. Soybean Assoc., published in Soybean Digest 10 (11) : 40-42.
(25) Krober, Orland A. and Collins, F. I.
1948. Effect of Weather Damage on the Chemical Composition of Soybeans. Jour. Amer. Oil Chemists' Society, 25 (8) : 296-298.
(26) Larmour, R. K., Sallans, H. R., and Craig, B. M.
1944. Hygroscropic Equilibrium of Sunflowerseed, Flaxseed and Soybeans. Canadian Jour. Research, Sec. F, 22 : 4.
(27) Lewis, A. J.
1948. Paints from Soybean Oil. Paper presented Cooperative Soybean Oil Mills Conference, Northern Regional Research Lab., Peoria, 3 pp.
(28) Mahr, J. A., and Fountain, H. S.
1949. Small Grain Drying Without Heat. Electricity on the Farm, (3) : 10, 11.
(29) Mayer, Lester B.
1949. Storage: How Much Does It Cost? Soybean Digest, 9 (10) : 6.
(30) Milner, Max.
1947. Why Does Grain Spoil in Storage? Feedstuffs, 19 (15) : 46, 47. Reprint from Minnesota Farm and Home Science (Minn. Expt. Station Publication)
(31) ----------, and Geddes, W. F.
1946. The Relation Between Moisture Content, Mold Growth, and Res-

piration of Soybeans. Cereal Chemistry, 23 (3) : 238-245.

(32) ----------
1946. Biological and Chemical Factors Involved in the Spontaneous Heating of Soybeans. Cereal Chemistry, 23 (5) : 449-470.

(33) ----------
1945. The Effect of Aeration, Temperature, and Time on the Respiration of Soybeans Containing Excessive Moisture. Cereal Chemistry, 22 (6) : 498-500.

(34) Milner, M., Warshowsky, B., Tervet, I. W., and Geddes, W. F.
1942-43. The Viability, Chemical Composition and Internal Microflora of Frost Damaged Soybeans. Oil and Soap, 19, 20 : 265-268c.

(35) National Soybean Crop Improvement Council.
1950. How Can You Grow More Soybeans Per Acre? Soybean News, 1 (4) : 1.

(36) National Soybean Processors Association.
1950. Year Book and Trading Rules. Revised. Chicago.

(37) Norton, L. J.
1949. Export Outlook for U. S. Fats, Oils and Oilseeds in Selected European Countries, U. S. Dept. Agr., Office of Foreign Agricultural Relations, Foreign Agr. Report No. 44, pp. 33-34.

(38) ----------
1951. Some comments on the Importance of a Market With Special Reference to Three War-Expanded Commodities. Ill. Farm Economics, U. of Ill. Agr. Ext. Service, (188) : 1107-1111.

(39) ----------
1941. When Should Grain Be Marketed? U. of Ill. Agr. Ext. Service, Cir. 516, 47 pp., illus.

(40) Otten, C. J., and Richey, P. S.
1950. Country Elevator Facilities. (Manuscript based on U. S. Dept. Agr. study of country elevators in Indiana.)

(41) Paarlberg, Don
1949. Prices of Soybeans and Soybean Products. Purdue U. Agr. Expt. Station Bul. 538, 48 pp.

(42) Ragsdale, J. M.
1950. Wheat in Missouri. The Farm Outlook, U. of Missouri Agr. Ext. Service, July, pp. 1-4.

(43) Ramsted, Paul E., and Geddes, W. F.
1942. The Respiration and Storage Behavior of Soybeans. Minn. Agr. Expt. Station Bul. No. 156, 54 pp. illus.

(44) Sabin, A. R.
1950. Marketing Channels and Margins for Soybeans and Soybean Products in Illinois. U. S. Dept. Agr., Bur. Agri. Econ., 24 pp. (Processed.)

(45) Sanders, J. H.
1944. Predicting the Flavor Stability of Soybean Oil. Oil and Soap, 21 : 357, 360.

(46) Shedd, C. K., and Cotton, R. T.
1949. Storage of Small Grains and Shelled Corn on the Farm. U. S. Dept. Agr. Farmers' Bul. No. 2009, 30 pp., illus.

(47) Sprague, P. E.
1944. Utilization of Soya Proteins in Industry. Soybean Digest, 4 (11) : 47, 48.

(48) Stahl, Benton
1947. Facts about Stored Grain. American Feed and Grain Dealers, 31 (4) : 16, 44.

(49) Strayer, George M.
1949. It's Time to Clean House. Soybean Digest, 10 (1) : 4.

(50) Tervet, I. W.
1943. Molds Injurious to Soybean Seed. Minnesota Farm and Home Science, 1 (1) : 13, 14.

(51) ----------
The Influence of Fungi on Storage, On Seed Viability and Seedling Vigor of Soybeans.
1945. Phytopathology, 35 (1) : 3-15.

(52) U. S. Dept. Agr.
1942. Store Soybeans Dry. Clip Sheet, No. 1253, July 5.

(53) ----------
1951. Recent Trends in Drying Oils. Fats and Oils Situation, U. S. Bur. Agr. Econ., Dec. 1950-Jan. 1951, pp. 11-22.

(54) Zeleny, Lawrence
1948. Chemical and Nutritive Changes in Stored Grain. Am. Assoc. Cereal Chemists Transactions, 6 (2) : 112-122.

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