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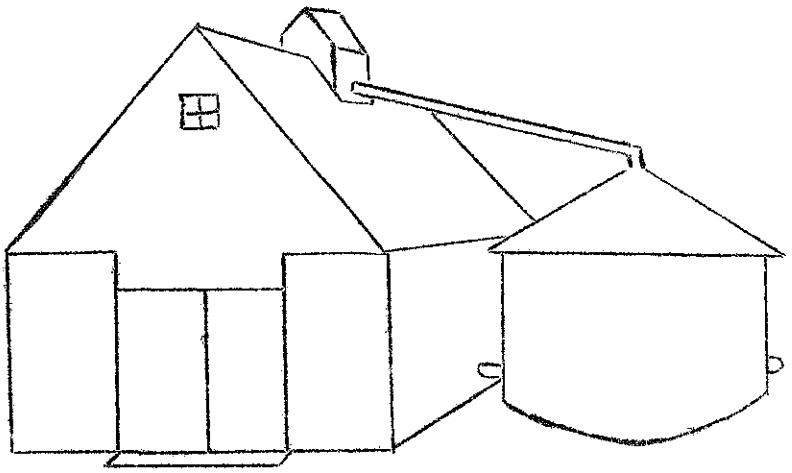
SHELLED CORN DRYING AND STORAGE CONSIDERATIONS



Charles H. Cuykendall
George L. Casler

Department of Agricultural Economics
New York State College of Agriculture
A Statutory College of the State University
Cornell University, Ithaca, New York

Shelled Corn Drying and Storage Considerations

The tables and calculations in this booklet are to assist corn buyers and sellers in their corn drying, storing and marketing decisions. 1/

CONTENTS

TABLES

1/ See also a companion publication A.E. Ext. 572 "Buying and Selling Shelled And Ear Corn At Various Moisture Levels", G. L. Casler and C. H. Cuykendall, 1970.

Calculation of Grain Shrinkage

In a kernel of corn only the dry matter has economic value. To make comparisons between different moistures in corn kernels, calculations are made to put all corn on an equivalent 15.5% kernel moisture.

When a quantity of grain is dried, some of the water is evaporated and some fines are lost. This loss is expressed as shrinkage. The amount of shrink depends on these factors:

a) The beginning kernel moisture

b) The final kernel moisture after drying

c) The dry matter loss (fines) in drying expressed as invisible loss

To calculate the amount of shrink as a percent, the following formula is used:

$$\% \text{ Grain Shrink} = \left[100\% - \left(\frac{100 - \% \text{ kernel moisture in wet corn}}{100 - \% \text{ kernel moisture after drying}} \times 100\% \right) \right] + \underbrace{.5\%}_{\text{invisible loss}}$$

$$\text{e.g. } \% \text{ Grain Shrink} = \left[100\% - \left(\frac{100 - 24}{100 - 15.5} \times 100\% \right) \right] + .5\%$$

$$= \left[100\% - 89.4\% \right] + .5\%$$

$$= 10.56\%$$

Using the above equation and any beginning or final moisture the resultant shrinkage can be calculated. Table 1 is a grain shrinkage table based upon this mathematical relationship and can be used directly to determine percent shrinkage. One should note that a 10 percentage point change in moisture is equal to more than a 10% shrink. For example 25.5% to 15.5% equals 12.33% shrink.

After you have determined the shrinkage as a percentage, multiply this by the quantity of wet grain in any units: bushels, tons, or pounds.

e.g. 2000 pounds wet grain (25.5%) x 12.33% = 246.6 pounds shrinkage to 15.5%

1 ton wet grain (25.5%) x 12.33% = .1233 tons shrinkage to 15.5%

35.71 bushels wet grain (25.5%) x 12.33% = 4.40 bushels shrinkage to 15.5%

Calculation of Net Dry Grain

To obtain the percent net dry grain subtract the shrinkage from 100%. e.g. 25.5% initial moisture to 15.5% dry = 12.33% shrinkage: 100% -12.33% = 87.67% net dry grain. Rather than calculate the amount of shrinkage you can calculate the tons, pounds, or bushels remaining after the moisture change by multiplying the wet quantity times the appropriate net dry grain percentage. e.g. 35.71 bushels wet grain (25.5%) x 87.67% = 31.31 bushels net dry grain at 15.5%. The net dry grain figures can be found on table 2 or by subtraction of the shrinkage from 100%.

Table 1. Grain Shrinkage Table 1/

Beginning Moisture Percent	Shrinkage When Grain is Dried to These Levels					
	12.0	13.0	14.0	15.0	15.5	16.0
15.5	4.48	3.37	2.24	1.09	--	--
18.0	7.32	6.25	5.15	4.03	3.46	2.88
20.0	9.59	8.55	7.48	6.38	5.83	5.26
21.0	10.73	9.70	8.64	7.56	7.01	6.45
22.0	11.86	10.84	9.80	8.74	8.19	7.64
23.0	13.00	11.99	10.97	9.91	9.38	8.83
24.0	14.14	13.14	12.13	11.09	10.56	10.02
25.0	15.27	14.29	13.29	12.26	11.74	11.21
25.5	15.84	14.87	13.87	12.85	12.33	11.81
26.0	16.41	15.44	14.45	13.44	12.93	12.40
27.0	17.55	16.59	15.62	14.62	14.11	13.60
28.0	18.68	17.74	16.78	15.79	15.29	14.79
29.0	19.82	18.89	17.94	16.97	16.48	15.98
30.0	20.95	20.04	19.10	18.15	17.66	17.17
31.0	22.09	21.19	20.27	19.32	18.84	18.36
32.0	23.23	22.34	21.43	20.50	20.03	19.55
33.0	24.36	23.49	22.59	21.68	21.21	20.74
34.0	25.50	24.64	23.76	22.85	22.39	21.93
35.0	26.64	25.79	24.92	24.03	23.58	23.12

1/ Including an invisible loss of 1/2 %.

Table 2 . Net Dry Grain 1/

Beginning Moisture Percent	When Dried to These Moisture Levels					
	12.0	13.0	14.0	15.0	15.5	16.0
15.5	95.52	96.63	97.76	98.91	--	--
18.0	92.68	93.75	94.85	95.97	96.54	97.12
20.0	90.41	91.45	92.52	93.62	94.17	94.74
21.0	89.27	90.30	91.36	92.44	92.99	93.55
22.0	88.14	89.16	90.20	91.26	91.81	92.36
23.0	87.00	88.01	89.03	90.09	90.62	91.17
24.0	85.86	86.86	87.87	88.91	89.44	89.98
25.0	84.73	85.71	86.71	87.74	88.26	88.79
25.5	84.16	85.13	86.13	87.15	87.67	88.19
26.0	83.59	84.56	85.55	86.56	87.07	87.60
27.0	82.45	83.41	84.38	85.38	85.89	86.40
28.0	81.32	82.26	83.22	84.21	84.71	85.21
29.0	80.18	81.11	82.06	83.03	83.52	84.02
30.0	79.05	79.96	80.90	81.85	82.34	82.83
31.0	77.91	78.81	79.73	80.68	81.16	81.64
32.0	76.77	77.66	78.57	79.50	79.97	80.45
33.0	75.64	76.51	77.41	78.32	78.79	79.26
34.0	74.50	75.36	76.24	77.15	77.61	78.07
35.0	73.36	74.21	75.08	75.97	76.42	76.88

1/ Including an invisible loss of 1/2%

Market Losses From Overdried Corn

Corn is bought and sold based upon 56.0 pounds being an equivalent bushel and containing 47.32 pounds of dry matter. If a grower has corn below 15.5% moisture he is marketing more pounds of dry matter in a 56.0 pound unit then is required. Most often he is not paid for the extra dry matter. The value of this extra dry matter that is in place of the water driven off is given in table 3. The lower the dried moisture level the greater the dry matter loss when sold based on 56.0 pound bushel weight. If this corn is fed to livestock they will get the full value of this extra dry matter as it is of no concern whether livestock obtain their water from a tank or in the corn. People who feed overdried corn should reduce the amount fed in relation to a standard bushel the same as they increase the amount fed when feeding high moisture corn.

It requires more fuel (energy and the resulting cost) to dry corn from 12% to 11% kernel moisture than from 20% to 19%. A farm manager that overdries will find his drying charges higher from overdrying not only from removing more water but also from having to remove additional internal moisture which comes out harder.

One must recognize that corn needs to be overdried to be safely stored. The 15.5% moisture kernel is marketable corn but 13 to 14% moisture kernels are needed if it is to be stored during the following spring warm up. For longer term storage of 2 or more years most people recommend 11 to 12% moisture levels as insurance that the corn will not go out of condition. Anyone drying corn will find that the final moisture level is one of safety first yet recognizing that lower levels are more costly in terms of drying cost and dry matter penalties if marketed without a premium.

Table 3 gives the market losses from overdrying corn. With number 2 corn (15.5%) priced at $1.10 per bushel every bushel dried to 10% moisture would have 7¢ worth additional dry matter in it than the standard bushel. The extra water driven off is replaced by valuable dry matter when 56 pounds of corn are sold. The table only includes the value of the additional dry matter marketed when overdried and not the additional fuel cost to get the kernel moisture down to overdried levels. This overdrying fuel charge would be from 1 to 3¢ additional. So one might expect the losses on the above overdried example to be 7¢ dry matter loss plus at least a 2¢ additional fuel cost. The 9¢ loss (when marketed) from mismanagement in addition to other normal drying costs would make costs of the system more expensive when compared to commercial drying charges. In some isolated cases livestock feeders are willing to pay a partial premium over number 2 corn price to get this corn of higher dry matter content.

Table 3. Marketing Losses From Drying Corn Below 15.5% Moisture 1/

Final Dried Kernel Moisture (Percent)	Market Receipts Paid to Farmers Per 56 lbs.	Dry Matter Value Per 56 lbs.	Loss From Overdrying 2/ Cents/Bushel
	Number 2 corn priced at $1.00/bushel		
9.0	$1.00	$1.08	8¢
10.0	1.00	1.07	7
11.0	1.00	1.05	5
12.0	1.00	1.04	4
13.0	1.00	1.03	3
14.0	1.00	1.02	2
15.5	1.00	1.00	0
	Number 2 corn priced at $1.10/bushel		
9.0	$1.10	$1.18	8¢
10.0	1.10	1.17	7
11.0	1.10	1.16	6
12.0	1.10	1.15	5
13.0	1.10	1.13	3
14.0	1.10	1.12	2
15.5	1.10	1.10	0
	Number 2 corn priced at $1.20/bushel		
9.0	$1.20	$1.29	9¢
10.0	1.20	1.28	8
11.0	1.20	1.26	6
12.0	1.20	1.25	5
13.0	1.20	1.24	4
14.0	1.20	1.22	2
15.5	1.20	1.20	0
	Number 2 corn priced at $1.30/bushel		
9.0	$1.30	$1.40	10¢
10.0	1.30	1.38	8
11.0	1.30	1.37	7
12.0	1.30	1.35	5
13.0	1.30	1.34	4
14.0	1.30	1.32	2
15.5	1.30	1.30	0
	Number 2 corn priced at $1.40/bushel		
9.0	$1.40	$1.51	11¢
10.0	1.40	1.49	9
11.0	1.40	1.47	7
12.0	1.40	1.46	6
13.0	1.40	1.44	4
14.0	1.40	1.42	2
15.5	1.40	1.40	0
	Number 2 corn priced at $1.50/bushel		
9.0	$1.50	$1.62	12¢
10.0	1.50	1.60	10
11.0	1.50	1.58	8
12.0	1.50	1.56	6
13.0	1.50	1.54	4
14.0	1.50	1.53	3
15.5	1.50	1.50	0

1/ Source: FM-122 University of Minnesota, C. Cuykendall & L. Christenson, 1967.

2/ This does not include any fuel costs required to get to this moisture level.

How Much Can You Afford for a Grain Drying System?

Many producers are faced with the question, "How many dollars can I afford to invest in a new drying and handling system for shelled corn?" The answer to this depends on alternatives available and volume to be dried annually. One might design a drying system because of show or pride, speed of handling, lack of alternatives, etc. and other growers want to set up a system only if it results in lower cost than their alternatives. This worksheet is designed to determine the break-even investment which will make a corn grower equally well off dollarwise as the commercial alternative. After working your case through you will have to shop for the system to meet your needs and compare it to see if it will result in a higher or lower cost, than commercial drying.

Worksheet to Calculate Investment in Drying Equipment
Compared to Alternative Drying Charge

1. Shrinkage: You can not avoid the shrink no matter where or when grain is dried. Therefore make all comparison of costs on a net dry grain basis (15.5% kernel moisture for corn).

	Example Based on Shelled Corn (15.5%)	Your Farm
	--cents per dry bushel--	
2. Commercial or Alternative Drying Costs: Use a harvested average moisture level for selection of the specific alternative drying charge (e.g. 25% moisture). This is the alternative amount you would have per dry bushel to cover your drying, handling and risk costs.	13.6¢	_____
3. Less your estimated drying gas and electricity costs on a dried bushel basis. (Also add costs of any additional labor need as a result of drying operation). For this cost use your past records or those of neighbors with similar drying systems. This cost often is between 4 and 7¢ per dry bushel depending upon points removed and weather factors.	5.6¢	_____
4. Amount remaining to cover ownership costs of the system (2-3). This is the amount that can be capitalized into your complete drying system.	8.0¢	_____
5. Bushels of corn (15.5% basis) to be dried annually with the system.	20,000	_____
6. Break-even annual ownership costs - (Multiply line 4 times line 5) This amount could be applied annually on the fixed costs of ownership of the system.	$1600.00	_____

	Example Based on Shelled Corn (15.5%)	Your Farm

7. Estimation of annual ownership costs of the drying system based on a percent of purchase price.

Overhead Item	Percent	
Depreciation (8 yrs.)	12.5	_____
Interest ($\frac{\text{annual rate}}{2}$)	4.0	_____
Repairs	4.0	_____
Insurance	.5	_____
Total	21.0%	_____

8. Line 6 divided by line 7 expressed as a decimal.

Break-even Annual Ownership Costs / Annual Ownership Costs as a Percent of Purchase Price	$\frac{1600}{.21}$	_____

9. The answer equals break-even investment for drying and handling equipment. $7,600 _____

10. Other Considerations: The above method gives an investment figure based on the data you supply. It does not include risk of grain going out of condition; fixed costs of present equipment nor the availability of labor or commercial drying at harvest time. Each of these items should be considered in deciding the best alternative. If the price you must pay for a system is more than the break-even investment maximum it is highly likely your business is not large enough to justify that system. Alternatives are to continue selling wet and pay the drying, or consider joint ownership or custom work to put more bushels through the system annually. By mismanagement and overdrying the potential profits gained by on the farm drying can sometimes be lost. Therefore, alternative use of management and capital must be considered after any budgeted change in the farm business.

Table 4 shows the break-even investment possibilities under varying returns to overhead costs and increasing quantities of grain dried. 1/ You can use the worksheet for your farm or if your fixed cost percentages are the same as the example (21% of purchase price) you may go directly to the table to obtain investment figure to adjust for your farm situation. For example if you overdry and fuel costs are increased by 2¢ under the preceding assumption this leaves only 6¢ per bushel to be capitalized over the 20,000 bushels or a break-even investment of $5700 rather than $7600.

1/ For a general discussion selecting grain drying methods, performance relationships and estimated costs under Midwest conditions see "Selecting a Grain Drying Method" AE-67, Coop. Ext. Service, Purdue University, October 1966.

Table 4. Break-even Investment for Drying and Handling Equipment 1/

Cents Per Bushel (15.5%) For Overhead Costs	Annual Bushels to Dry (15.5% Basis)					
	5,000	10,000	15,000	20,000	30,000	40,000
4¢	$1000	$1900	$2900	$3800	$5700	$7600
5	1200	2400	3600	4800	7100	9500
6	1400	2900	4300	5700	8600	11400
7	1700	3300	5000	6700	10000	13300
8	1900	3800	5700	7600	11400	15200
9	2100	4300	6400	8600	12900	17100
10	2400	4800	7100	9500	14300	19000

1/ Based upon annual overhead costs of 21% of purchase price. Investments rounded to the nearest $100.

What Does It Cost To Store Shelled Corn 1/

The purpose of this section is to help to determine the relative costs of shelled corn storage. Your first decision is to determine whether to store or sell at harvest. Your decision to store should be based upon: (a) availability and convenience of home or commercial facilities, (b) harvest price and discounts or premiums, (c) your costs of storage vs. outlook for seasonal price change, (d) additional requirements of artificial drying, labor, and cash availability. You will then have to weigh the economics of home vs. elevator storage which is a function of all the above considerations and length of storage. If you store, then you should consider the merits and costs of the government grain seal program. Lastly, what potential price rise would be required for you to store through 2, 4, 8 months, etc. The example in Table 5 has been worked through on the basis of 9 months of storage. You should consider this only as one example period of time and calculate your approximate costs for your period of storage in the blanks.

Table 5. Costs Incurred When Storing Shelled Corn

Months of Storage -	Approx. Costs For Storing Shelled Corn: Typical Farm Bin 9 Months	Typical Elevator 9 Months	Your Costs Months
	cents per bushel		
Items			
1 - Bin Use Cost	3.5¢	--	_____
2 - Elevator Storage (1¢ per 20 days per bu.)	--	13.5¢	_____
3 - Extra Handling	2.5	--	_____
4 - Losses and Damage	2.0	--	_____
5 - Interest on Commodity Investment 8% on price of $1.10 per bu. (use cost). Use a lower percent if sealed under governmental loan.	6.3	6.3	_____
6 - Commodity Insurance (41¢ per $100 insured)	.4	--	_____
7 - Total Storage Cost	14.7¢	19.8¢	_____

1/ Source FM-125R University of Minnesota, C. Cuykendall & L. Christenson, 1968

Data and Judgments to Assist You to Determine Your Storage Costs 1/

Column 1: ON THE FARM - Not Under Government Chattel

1. Bin Use Cost. Multiply purchase price per bushel times annual use cost (depreciation, interest, repair and maintenance, insurance, and taxes).

   e.g. 30¢ per bushel times 11.7%

3. Extra Handling. This is the charge for the in and out labor and power plus the year around sampling and checking on condition and quality. Estimated at 2.0 to 2.5¢ per bushel.

4. Losses and Damage. Corn loses weight as a result of handling, deterioration, rodent and insect damage. Depending upon the storage structure add up to a 2¢ per bushel for losses.

5a. Interest On Commodity Investment. The producer with a stored commodity has no rate of return on the corn which represents capital invested. To compare alternatives he must charge against the practice a rate of return he would expect to pay for the use of additional funds.

$$110¢ \times .08 \times \frac{1}{12} \text{ year} = .7¢ \text{ per bushel per month}$$

Multiply the monthly rate times months stored to determine per bushel charge.

5b. Sealed Under Government Chattel. An interest bearing chattel is an expense until commodity is bought back. Per bushel monthly charges equal county loan rate times interest rate times period of the loan. Assuming you retained control of the commodity and bought back July 31 the loan interest would be:

$$110¢ \times .036 \times \frac{1}{12} \text{ year} = .33¢ \text{ per bushel per month}$$

Use Cost on Corn Not Eligible For Loan Collateral. Usual practice to protect producer and loaner is to seal the bin at 90% of estimated volume. Thus 10% of the crop cannot be used as collateral for the chattel mortgage. Use cost on the balance is calculated at:

$$110¢ \times .08 \times \frac{1}{12} \text{ year} \times .10 = .07¢ \text{ per bushel per month}$$

$.33 + .07 = .4¢$ per month x 9 months = $3.6¢$ instead of non-sealed use cost of $6.3¢$

6. Commodity Insurance. Add in the insurance premium of the stored crop. e.g. 41¢ per $100 insured resulting in an annual charge of $0.4¢$ per bushel.

Column 2: TYPICAL ELEVATOR STORAGE - Not Under Government Chattel

2. Elevator storage is often 1.5¢ per bushel per month. Multiply monthly rate times months stored to determine storage cost.

5a. Same as in A.

1/ Numbers refer to items on page 9.

Graphical Analysis

The attached graph shows accumulated costs by months based upon the preceding example.

Line I represents the total costs of home storage for any individual month. The slope of the line or the amount if increase from one month to the next is the amount of the opportunity cost of funds tied up. e.g. .7¢ per bushel per month. At point A one has incurred all the in and out charges and the decision to storage one additional month should be based upon the marginal cost marginal revenues principle.

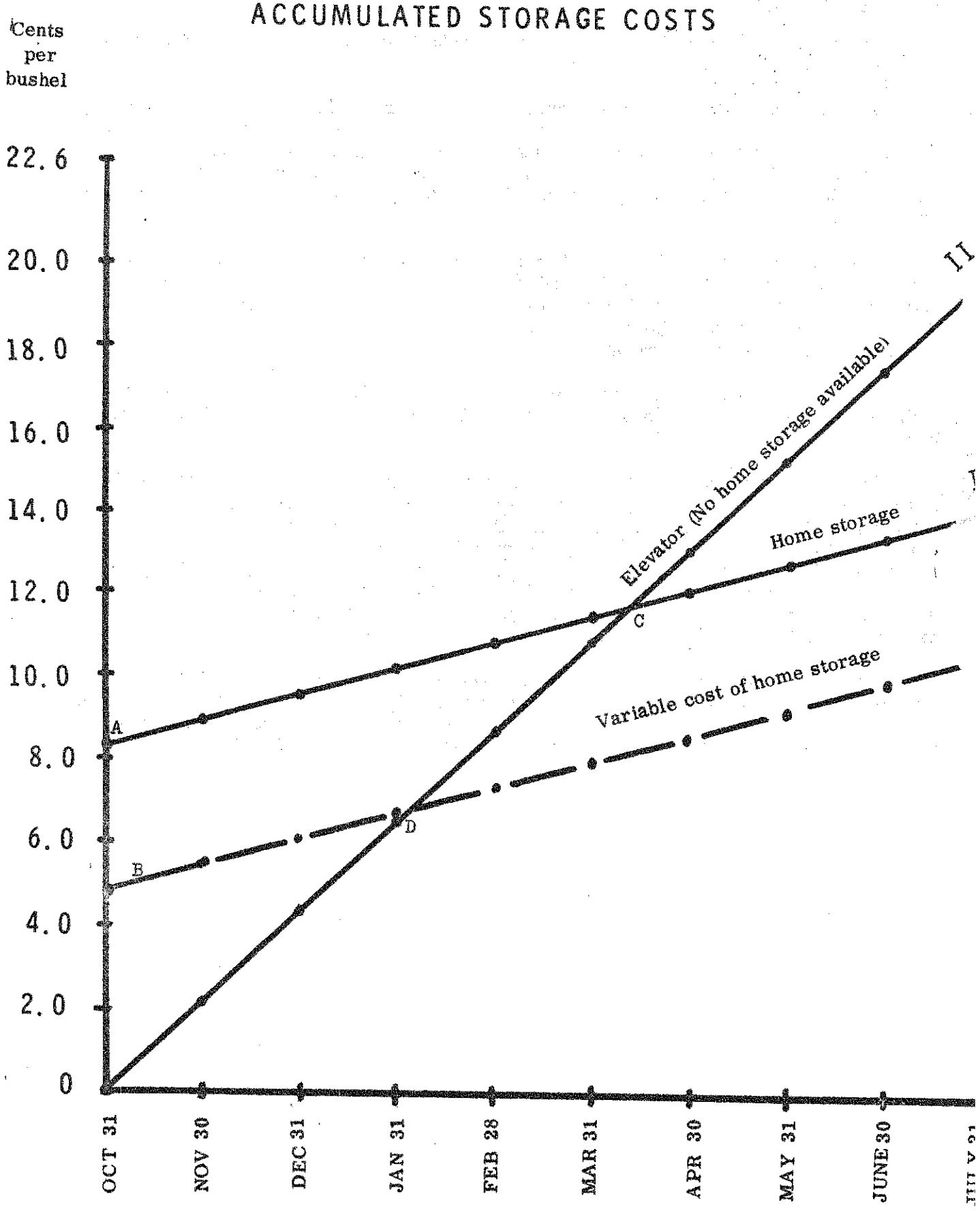
Line III represents the variable costs of home storage (total costs minus fixed bin costs). Point B is determined by total costs at: A (8.4¢) minus fixed bin cost (3.5¢). After one has the bin and if there is no other use for it this 3.5¢ is a sunk cost and the decision to store or sell should be made using this line. The slope is the same as line I.

Line II represents the costs of elevator storage. It is a uniform cost of 1.5¢ per bushel per month plus the opportunity cost of funds tied up .7¢ per bushel per month.

Point C represents the break-even point between covering all costs of home storage vs. commercial storage. When considering buying a storage unit one would choose purchase if the storage period was later than the break-even date of mid-April. If one were considering new storage both the fixed and variable costs are relevant. Line I assumes use of the storage every year for 15 years to get the average fixed costs down to 3.5¢ per bushel. Years in which the structure is not used still incurs a fixed cost of the same amount. If one was desiring short time storage the commercial facilities are more attractive.

Point D represents the break-even point when the fixed costs of the bin are ignored. Decisions to store at home or commercially now have a break-even date of mid-February. Storage up to that date would be less expensive commercially and longer term home storage cheaper than commercial if carried beyond that date.

ACCUMULATED STORAGE COSTS



Storage Costs Vs. Storage Returns

Cash grain farmers who hold dry shelled corn do so with the expectation that the stored price will exceed the harvest time price by more than the additional costs incurred. They must have an estimation of the costs of storage in order to compare this with the monthly price change of corn.

The 10 year historical average data for the state can be used only as a lesson in history. Tables 6A and 6B represent what has happened to corn prices over the last 10 years.

Table 6A shows the 10 year average monthly corn price changed 8 cents between November and the following May. This would represent the average expected return for holding that period of time. Local conditions of surplus and deficit feed areas cause these figures to move up or down and local prices should be used to make your marketing decisions.

The price change from November to May is shown annually in Table 6B. One can see little variation in the 1960-64 period and more variability in the 1965-69 period. Two years, in this latter period, the price change from harvest to May was not enough to cover the variable costs of storage.

In retrospect one can look back at the historical outcome of selling during the high month whenever it occurred. This shows a similar uniform price pattern in the 1960-64 period but the peak occurred sporadically in each of 5 different months.

The latter 5 years finds even more price variability and the high month tends towards the latter part of the crop year. The 1969 crop which was marketed in 1970 shows an abnormally high return to storage because of the uncertain effects of southern corn leaf blight.

After once deciding to put corn into storage you incur a 7 to 9¢ fixed cost whether storing for 1 week or 50 weeks. Your decision to continue storing or sell now is one of how much additional cost will be incurred vs. the change in market price. The previous graph and calculations indicate that the cost of storing 1 additional month (corn $1.10) would be around .7¢ per bushel. Any price change in excess of this added cost would be profitable.

From this historical glance one can see there are many price marketing factors to be considered and no "pat" answer can be used in one's marketing decision. The price changing forces of locality, exports, feed requirements, carryover, forthcoming production and all other utilization factors affect the cycle of stored corn prices.

Table 6A.

Corn Prices Received by Farmers, New York Mid-Month Average 1960-1969 1/

November	$1.24	May	$1.32
December	1.27	June	1.32
January	1.28	July	1.32
February	1.30	August	1.31
March	1.31	September	1.31
April	1.31	October	1.27

Table 6B.

Corn Prices Received by Farmers, New York Mid-Month Average Price Change From November to Following May and From November to Highest Month Thereafter 1/

Crop Year	Price Change (cents per bushel) November to Following May	November to Following High Month	
1960-61	$.08	$.11	March
1961-62	.07	.10	June
1962-63	.09	.13	August
1963-64	.10	.11	September
1964-65	.08	.09	February
5-yr. average (60-64)	$.08	$.11	
1965-66	$.13	$.23	September
1966-67	.01	.03	February
1967-68	.03	.06	March
1968-69	.17	.17	May
1969-70	.09	.27	September
5-yr. average (65-69)	$.09	$.15	
10-yr. average (60-69)	$.08	$.13	

1/ Agricultural Statistics, New York Crop Reporting Service; AMA Release No. 115, 119; 1968, 1969; N.Y.S. Agricultural Prices AMA Release No. 79, 1964.