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Some Economic Considerations in Farm Machinery

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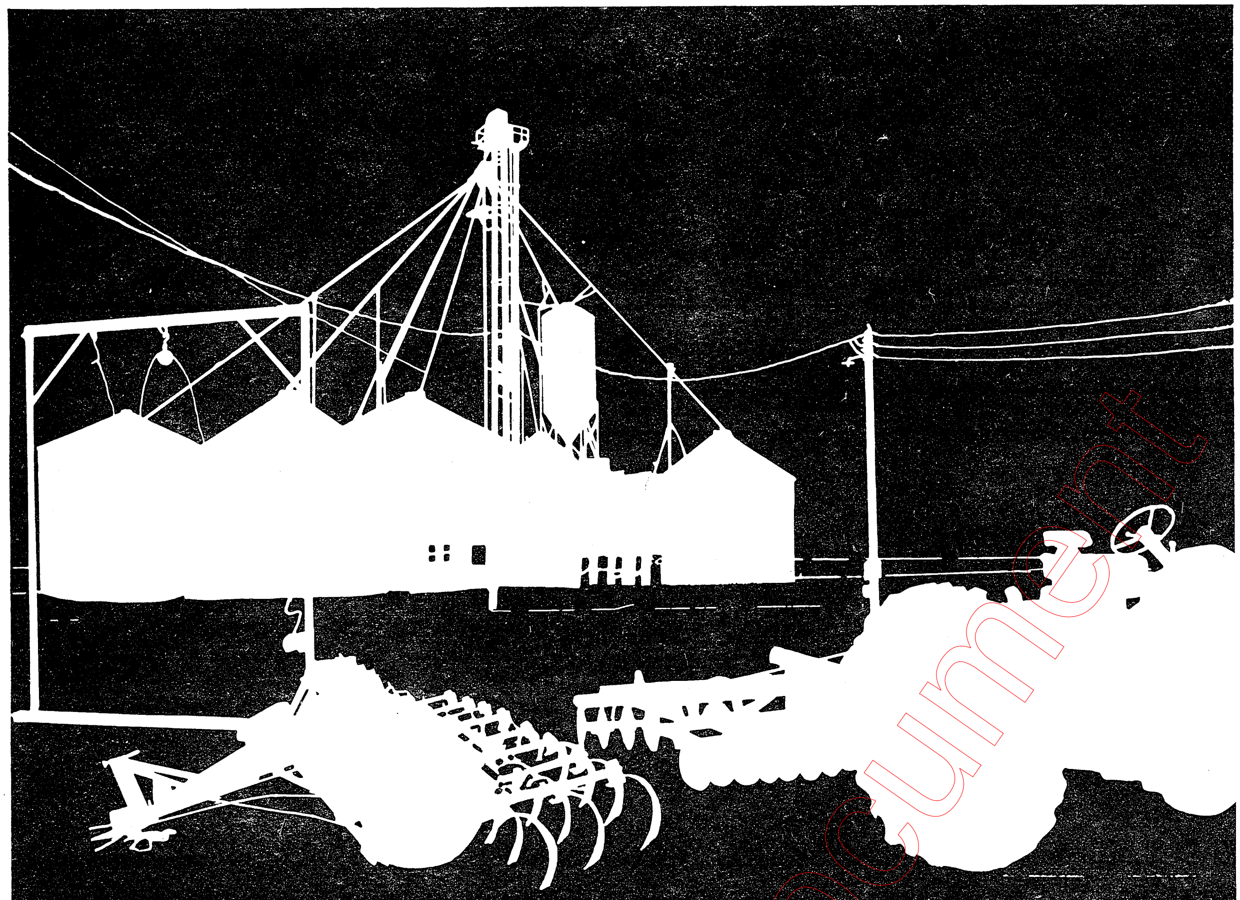

Some economic considerations in farm machinery

Cooperative Extension Service • PURDUE UNIVERSITY • Lafayette, Indiana

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Cooperative Extension Work in Agriculture and Home Economics, State of Indiana, Purdue University and U. S. Department of Agriculture Cooperating. H. G. Diesslin, Director, Lafayette, Ind. Issued in furtherance of the Acts of May 8 and June 30, 1914.

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IV

SUMMARY AND CONCLUSION

1. Farm machinery represents a large and growing item of investment and expense on most farms. The average replacement cost for farm machinery on Indiana Farm Account Cooperators' farms in 1966 was approximately $40,000. Average annual power and machinery costs were $9602 (Table 2).

2. It is important to make the most of every dollar spent for equipment. High profit operators usually save several hundred dollars on power and equipment compared to low profit operators with the same size business. Although it is important to keep costs down, it is far more important to keep output high by getting the job done right, on time, and in big volume (Page 1).

3. The optimum time to trade farm equipment is largely determined by the amount of annual use, obsolescence, and the financial position of the operator. On most farms machinery cannot be used to full capacity. Depreciation, interest, taxes and insurance costs decline slightly more rapidly than repair costs increase. This means that strictly from a cost standpoint, small savings can be made by keeping equipment until it is worn out. After an initial rapid decline in annual machinery cost during the first few years of equipment life, the annual cost of owning a machine changes only slightly from year to year. Thus, if obsolescence or tax saving indicates an early trade or if capital shortage or limited use indicates a late trade, either may be justified (Page 17).

4. Big equipment is necessary to be competitive. Since there is generally a time limitation on when most farm operations can be performed, large sized equipment is necessary to achieve maximum yield and output. From a cost viewpoint, because labor charges constitute a large proportion of total per acre costs, bigger machinery which can accomplish a job in a shorter time period also has lower total per acre costs when labor costs are high (Page 19).

5. Rules of thumb can be helpful in estimating fixed and variable costs, what to buy and when to trade (Page 10).

6. To be most competitive, farmers must use the largest equipment available to them on a practical basis (Page 20).

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SOME ECONOMIC CONSIDERATIONS IN FARM MACHINERY

N. S. Hadley, Stanley D. Parsons and D. Howard Doster 1/
Agricultural Economists

There are two ways in which the farmer can increase his returns. He can increase per unit profit, or he can increase volume or both. On the output side, holding costs down is important, but getting the job done right, on time and in big volume is far more important. When comparing high and low profit farmers, differences in labor, power and machinery costs may be several hundred dollars, but the difference in output may be several thousand dollars. This is clearly borne out by the figures in Table 1, which shows the difference in power and machinery costs and labor income for farmers who participate in the Indiana Farm Accounts program conducted by Purdue University.

Table 1. Variation in labor power and machinery and labor income, on account keepers' farms in Central Indiana in 1963.

Size and Profit	Power & Mach. Cost/PMWU a/	Labor, Power & Mach. Cost/ PMWU	Labor Income
Small Most Profitable	$ 9.86	$22.71	8,441
Small Least Profitable	11.83	25.66	1,610
Medium Most Profitable	13.36	28.79	12,033
Medium Least Profitable	13.81	26.17	232
Large Most Profitable	12.58	25.91	19,890
Large Least Profitable	13.62	26.60	1,234

a/ PMWU = Productive man work unit (the amount of work accomplished by one man in a 10-hour day).

Capital invested in farm machinery constitutes about one-third of the total non-land investment on Indiana farms. Table 2 shows that the amount of capital invested in machinery is large and is increasing.

Since machinery represents a major and growing investment, obviously it is important that the farmer be able to evaluate whether he has the optimum investment in machinery.

1/ Assisted by Samuel D. Parsons, Extension Agricultural Engineer.

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Table 2. Indiana farm account cooperators machinery investment per farm and average annual power and machinery cost per farm.

	1950-54	1955-58	1959-63	1963	1966
Investment a/	$7,336	$9,036	$10,916	$12,094	$17,098
Power & Machinery Cost	3,877	5,043	6,073	6,570	9,602

a/ These are depreciated figures and represent about 40 percent of replacement cost.

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Since almost without exception, farmers are faced with limited resources in the form of land, labor and capital, it is important to realize that resources allocated to one enterprise cannot be allocated to another. In order to maximize total profits, any resource allocation to one enterprise must be considered in the light of how it affects other enterprises.

This is achieved by allocating costs to inputs for which more than one enterprise competes. For example, the farmer with limited spring labor must decide whether he will use spring labor to produce corn or to farrow more sows. If the return from an extra hour of labor in corn production is $12 (assuming additional land is available for corn) each hour he spends on hogs is worth $12 in "opportunity costs". This is because if he had spent that hour in producing corn, he would have made a return of $12. Similarly a farmer who invests $20,000 in a new combine is faced with the alternative opportunity of making a 4 percent return if he had invested the money in the savings bank. So part of the "cost" of the new combine is the interest the money would have earned elsewhere. By using the idea of "opportunity costs" in enterprise budgets, farmers can cross check the effectiveness of their overall farm plans.

The purpose of this publication is to provide tools which a farmer might use in selecting that set of machinery which will enable him to maximize profits.

The machinery costs and other figures used are averages which have been collected from various sources. They demonstrate the principles involved and show the differences that exist between various machinery sizes. Whenever possible, farmers should use their own data instead of the figures shown here. These analytical procedures are aids in the decision-making process and are no better than the facts and judgments used with them.

COST

This method involves a comparison of the costs, including the opportunity cost of capital and labor, for various machinery systems which can be used to get a specific job or series of related jobs done at least cost without a sacrifice in output. The total cost involved may be divided into (1) the fixed costs and (2) variable costs. Fixed costs are the ownership or overhead costs and are the costs incurred whether the machinery is used or not. Depreciation, interest on capital invested, repairs, taxes, insurance and shelter are considered to be fixed costs. Repairs are associated with amount of use, but because they tend to come in quantity, they are sometimes considered as fixed costs. Operating or variable costs include fuel, lubricants, operator's labor and sometimes repairs.

ANNUAL OVERHEAD COSTS (Fixed or Use Costs) - the D-I-R-T-I-S

D - Depreciation

This is the term used for allocating the original cost of the input item (tractor, disc, et cetera) over the useful life of the item. Whereas certain inputs are consumed in a production process (fuel is burned and seeds only sprout once) other inputs are only partially used up. Thus for example, a tractor may be used over several years of corn production. To determine the cost of each corn crop only a portion of the total tractor cost should be charged to each crop. The proportion of the original cost to be allocated in any one year is largely a matter of judgment. For cost accounting purposes, depreciation may be regarded as the loss in market value of the machine. Remaining values of various types of equipment are listed in Table 3.

Table 3. Remaining value of farm machinery as percent of list price. a/

Beginning of Year	Wheel tractors	Combines, corn heads, windrowers	Forage harvesters, balers	All others
1	100.0	100.0	100.0	100.0
2	63.0	58.6	52.2	55.3
3	58.8	52.7	46.4	49.5
4	54.8	47.5	41.2	44.3
5	51.1	42.7	36.7	39.7
6	47.7	38.4	32.6	35.5
7	44.5	34.6	29.0	31.8
8	41.5	31.1	25.8	28.4
9	38.8	28.0	22.9	25.4
10	36.2	25.2	20.4	22.8
11	33.7	22.7	18.1	20.4
12	31.5	20.4	16.1	18.2

a/ Source: Wendell Bowers, "Costs of Owning and Operating Farm Machinery," University of Illinois A-Eng. 867. (Farmers who pay less than list price should reduce first year value accordingly).

Example: What would the remaining value of a $4,700 wheel tractor be when it is 5 years old?

At the end of 5 years or the beginning of the 6th year the table shows the remaining value to be 47.7 percent of its initial list price, or $2,242. One year later (beginning

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Table 4. Depreciation schedules approved by the Internal Revenue Service per $1000 of list price for all machines.

Year	Depreciation per year per $1000 of new cost		
	Straight Line (10%)	Declining Balance (20%) a/	Sum of Years b/ Digits
1	$ 90	$200.00	$163.64
2	90	160.00	147.27
3	90	128.00	130.91
4	90	102.40	114.54
5	90	81.92	98.18
6	90	65.53	81.82
7	90	52.43	65.46
8	90	41.94	49.09
9	90	33.55	32.73
10	90	26.84	16.36
Total	900	892.61	900.00
Salvage value	100	107.39	100.00
	$1000	$1000.00	$1000.00

a/ The depreciation rate is calculated as 20 percent of the value at the beginning of the year. For tax purposes, the rate may not be greater than twice the rate which would be used under the straight line method.

b/ With this system the numerator represents the useful remaining life of the machine and the denominator represents the sum of the number of years of life (1+2+3----10) or $\frac{10}{55}$ second year $\frac{9}{55}$, et cetera.

of the 7th year) the remaining value is 44.5 percent of $4,700, or $2,091. Depreciation for the 6th year would be $2,242 - $2,091, or $151.

Loss in market value or depreciation cost, results from age (obsolescence) and wear. A machine becomes obsolete when a new machine will do the job better or at less cost or both. Associated with wear is the increased risk of poor performance and breakdowns. Thus, factors which affect the amount of depreciation are: the expected useful life of the equipment, the amount of use, the kind of use, the care and skill of the operator, the shelter, the original quality of the machine, the timeliness and quality of repairs, and above all, obsolescence.

There are several methods of computing depreciation, and the methods vary depending upon the purpose. Different depreciation schedules are used to allocate costs, and such allocations differ according to the circumstances. Examples are presented in Table 4.

For tax purposes, the methods most commonly used by accountants are those approved by the Internal Revenue Service. These are straight line, declining balance and sum of the years digits methods (Table 4).

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A comparison of the three methods shown in Table 4 is shown below:

Assume a \$6000 tractor with a 10 percent salvage value and an expected life of 10 years.

Straight line: $\frac{\$\ 90}{\$1000} \times 6000 = \$540$ per year

Declining balance:

First year $\frac{\$\ 200}{\$1000} \times 6000 = \$1200$

Second year $\frac{\$\ 160}{\$1000} \times 6000 = 960$

Third year $\frac{\$\ 128}{\$1000} \times 6000 = 768$

Et cetera

Sum of the years' digits:

First year $\frac{\$\ 163.64}{1000} \times 6000 - 981.84$

Second year $\frac{\$\ 147.27}{1000} \times 6000 - 883.62$

The method selected for cost estimation will depend upon the degree of accuracy required and the ease of computation. Since most machinery suffers a high loss in market value in its early years of use, machinery kept for only a few years should be charged accordingly. The declining trade-in value (Table 3) is most accurate for this purpose. However, the average per annum cost for machinery kept until worn out will be about the same no matter which method of depreciation is used. For example, under the straight line method, the amount of depreciation in the first year is \$90 per \$1,000 value, while under the declining balance method it is \$200. Yet over the whole life the average annual cost is \$90 for the straight line and \$89.26 for the declining balance method. The actual loss in value is not affected by the method of depreciation used for tax purposes.

I - Interest on capital invested

The money invested in farm machinery cannot be used for other purposes, thus an interest charge should be made against farm machinery whether the money is borrowed or not. The interest rate used depends upon the alternative uses for which the money could be used. If so much money is available that surplus money is kept in a checking account that draws no interest, the rate would be zero. If money is kept in the savings bank and earns 4 percent interest, the rate should be 4 percent. It is also quite possible that money is in short supply and is borrowed at 7 percent in which case the rate must be 7 percent.

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R - Repairs

These are discussed in the variable cost section.

T - Taxes

Taxes vary from area to area, but in Indiana the cost is 1/3 of the value reported on the federal income tax depreciation schedule times the tax rate. If the tax rate is $4.50, the cost of taxes is 1.5 percent of undepreciated value. If the rate is $6.00, then the cost of taxes is 2 percent of real value.

I - Insurance

An average premium for farm machinery is about one-half of one percent of current value.

S - Shelter

A housing charge should be made whether the machinery is housed or not. If machinery is not housed, depreciation and maintenance costs will usually be higher. Housing costs usually average about 1.0 percent of current value.

VARIABLE OR OPERATING COSTS

These are the costs which vary in proportion with the amount of use of machinery. The main variable costs are repairs, fuel, oil and grease and labor.

Fuel, maintenance and labor costs are relatively constant throughout the life of the machine on a per hour basis. Repair costs on the other hand tend to increase as the machinery gets older.

Fuel, oil and grease

For convenience and simplicity, it may be assumed that fuel, oil and grease costs are the same for all machinery sizes, and that fuel costs are about 80 percent of fuel, oil and grease cost. Although larger machinery has a higher fuel consumption per hour, this is approximately offset by fewer hours of use, so that over a fixed acreage, the differences in fuel consumption is negligible. Table 5 shows the approximate hourly fuel requirement for different size tractors. For more detailed calculations, see Table 6.

Repair costs

These costs do not occur continuously but occur sporadically, as for example, when major overhauls are required or tires need replacing. Repair costs also vary according to the initial quality of the machine, the amount and type of use, the skill of the operator, shelter and maintenance practices and how repairs are made.

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Table 5. Gasoline consumption for farm tractors, average gallons per hour for tractors of specified sizes.

Tractor size moldboard plows	Gallons per hour
2-3	2.2
3	2.3
3-4	2.8
4	3.4
4-5	4.0
5-6	4.8

Source: Robert C. Suter and J. Weismiller, "The Costs of Operating Farm Tractors," Unpublished Paper, Purdue University, p. 16.

Table 6. Multipliers for fuel, oil and lubricating costs. a/ b/

	Fuel Consumption			Fuel oil and Lub. Cost		
Equipment	Gas	Dsl.	LPG	Gas	Dsl.	LPG
Two-wheel drive tractors Self-propelled combines Self-propelled swathers Hay balers with engine Forage harvester with engine Trucks and pickups	.69	.44	.76	.79	.51	.87
Four-wheel drive tractors Self-propelled forage harvesters	.46	.31	.53	.53	.36	.61
Crawler tractors Feed truck with power box	.36	.25	.42	.41	.29	.48

a/ Source: Wendell Bowers, "Costs of Owning and Operating Farm Machinery," University of Illinois A-Eng. 867.

b/ These values are 15 percent larger than the fuel consumption multiplier. This allows for 15 percent of the fuel cost to cover the cost of lubricants and filters. Multiply these rates by the fuel price and the equipment list price divided by $1,000 to obtain fuel and lubricant cost in dollars per hour. Fuel price is the actual cost per gallon after tax refunds and all rebates.

Example: What would be the average fuel consumption and operating costs for the $4,700 tractor if it burns gasoline with a net cost of 18¢ per gallon?

Fuel consumption - The average fuel consumption is $.69 \times \frac{\$4,700}{1,000}$ or $.69 \times 4.7 = 3.21$

Cost per hour - The cost per hour for fuel oil, grease, filters would be $.79 \times \frac{\$4,700}{1,000}$ or $.79 \times 4.7 \times .18 = \$.67$ an hour.

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Because of the large number of factors which affect the repair cost of farm machinery, estimates of repair costs also show a wide variation.

The figures in Table 7 show how repair costs increase with the use of the machinery. Note that repair costs start earlier and increase more rapidly for field equipment and combines than for tractors.

Labor costs

Labor costs are difficult to determine because they vary according to the skill of the operator, the time at which labor is available and alternative uses for the labor, both farm and non-farm.

What is labor worth? If it is hired labor, it can be valued at what it costs. Wages of hired workers may vary widely depending on the skill of the operator and the time of the year.

If it is family labor with little or no alternative use, it may be valued at a very low figure or it may be highly skilled and very valuable.

If it is the operator's labor, it almost surely will be valued at its opportunity cost. (How much can it be made to earn?)

Because hired labor is not unlimited, can be discharged if desired, and there are nearly always alternative uses for both hired and family labor, opportunity cost should always be considered in evaluating any kind of labor.

ESTIMATING ACRES PER HOUR

Operating (variable) costs vary with the amount of use. Unit costs of production are influenced by the amount of use over which fixed costs can be spread. To use both fixed and variable costs, it is necessary to measure the amount of use. A reasonably accurate way to calculate acres per hour of use is shown below:

$$\frac{\text{Speed (MPH) X width of implement (feet)}}{10} = \text{Acres per hour}$$

This equation is arrived at as follows:

1 acre equals 43,560 square feet. An implement 10 feet wide must travel 4356 feet to cover an acre. If the implement travels 1 MPH (5280 feet), it will cover an acre in $\frac{4356}{5280}$ or .825 hours.

No field machine operates at 100 percent efficiency, or to say it differently, no machine will operate 100 percent of the time it is in the field at its rated speed and

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Table 7. Accumulated repair cost per $1000 of list price.

a)i) Mowers, tillage equipment, ii) forage harvesters, balers and general machinery

Accumulated use (hours)	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
Accumulated repairs ($) i)	52	127	215	313	418	530	647	770	897	1029	1165	1304
ii)	27	72	126	189	258	333	413	498	587	681	778	878

b)i) Combines, self-propelled windrowers, ii) planters, seeders, sprayers

Accumulated use (hours)	100	200	300	400	500	600	700	800	900	1000	1100	1200
Accumulated repairs ($) i)	7	18	31	46	63	82	—	122	—	167	—	215
ii)	19	49	86	129	177	228	283	341	402	466	533	600

c) Wheel tractors

Accumulated use (hours)	500	1000	1500	2000	3000	4000	5000	6000	7000	8000	10,000	12,000
Accumulated repairs ($)	10	29	53	82	150	231	323	424	535	653	913	1200

Source: Adapted from "Cost of Owning and Operating Farm Machinery," Wendell Bowers, Univ. of Illinois, A-Eng. 867.

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Table 8. Hours per acre rule of thumb examples.

Operation	Speed x width	Acres/hour	Hours/acre
(1) Chop stalks (2 row)	$\frac{3.5 \text{ MPH} \times 6.7 \text{ ft.}}{10}$ =	2.345	.43
(2) Plow (5 bottom)	$\frac{4 \text{ MPH} \times 6.7 \text{ ft.}}{10}$ =	2.68	.37
(3) Disc (13 foot)	$\frac{5 \text{ MPH} \times 13 \text{ ft.}}{10}$ =	6.5	.15
(4) Plant (4 row)	$\frac{5 \text{ MPH} \times 13.3 \text{ ft.}}{10}$ =	6.65	.15
(5) Cultivate (4 row)	$\frac{3 \text{ MPH} \times 13.3 \text{ ft.}}{10}$ =	4.0	.25
		Total 5 different oper.	1.35

effective width. A field efficiency of 82.5 percent is reasonable for most tillage operations and some others. So, if it is assumed that field efficiency is 82.5 percent, then the above equation is correct.

To find the number of hours required per acre divide the acres per hour into 1. Examples are shown in Table 8.

TOTAL COSTS

The previously outlined principles enable the estimation of total costs, or per hour or per acre costs of owning and operating farm machinery to be calculated. In general, the procedure is to calculate the fixed costs and to add the variable costs.

The following are two methods of calculating fixed costs. The first method is a simple rule of thumb which permits rapid calculation of constant average annual costs over the life of the machinery. The second method enables the computation of annual costs which decrease as the machinery gets older, that is an approximation of the real life situation.

RULE OF THUMB METHOD

This method enables the calculation of the average annual cost of a machine as a percentage of its original cost. For example, for a machine costing $1,000 with an expected useful life of 10 years and where the interest rate is 6 percent of remaining value, the tax rate is 1.5 percent of remaining value, the insurance is 0.5 percent of remaining value, shelter is 1 percent of remaining value and the annual depreciation rate by the straight line method is 10 percent. The interest, taxes, insurance and shelter (ITIS) charge totals to 9 percent of remaining value (6 + 1.5 + 0.5 + 1 = 9). However, the ITIS charge should be converted to a percentage of original value. In the first year the ITIS charge is 9 percent of $1,000, in the second year it is 9 percent of $900 and so on, so that in the tenth year it is 9 percent of $100. For a machine which is kept for the

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whole of its expected life, this is an average of 9 percent of half its original value. Therefore, 9 percent of $500 = $45. Expressed as a percentage of original value, this is .5 x 9 percent of $1,000 or 4.5 percent of original value (4.5 percent x $1,000 = $45). Therefore, the average annual total fixed cost percentage multiplier is 10 percent for depreciation and 4.5 percent for ITIS or 14.5 percent for DITIS.

For a machine kept for less than its expected life, the depreciation rate is calculated as shown above, but the average ITIS charge must necessarily be greater. So for a machine with an expected life of 10 years which is kept for only 5 years, the rate would be calculated on the value midway between the original and remaining value at time of sale. Therefore, if the purchase price of a machine represents 100 percent and it is to be sold in 5 years with a remaining value of 50 percent, the average value would be 75 percent. The average annual charge then would be 75 percent of 9 percent = 6.75 percent. Adding the 10 percent depreciation charge yields a 16.75 percent total fixed cost multiplier.

The magnitude of the fixed cost multiplier will vary according to individual circumstances. Length of life, year of sale, interest rate, tax rate, and so forth all affect the magnitude of the multiplier. For example, consider three sets of equipment each costing $1,000:

Example (1) Expected life 20 years, depreciation rate 5 percent, interest rate 4 percent and taxes 1/3 of $4.50.

Example (2) Expected life 5 years, depreciation rate 20 per cent and interest rate 8 percent and taxes 1/3 of $4.50.

	Case 1			Case 2		
Depreciation			5.00			20.00
Interest	4%	÷ 2	2.00	8%	÷ 2	4.00
Taxes	1.5%		.75	1.5%		.75
Insurance	0.5%		.25	0.5%		.25
Shelter	1%		.50	1%		.50
% Annual use cost			8.50			25.50

Example (3) Expected life 10 years, depreciation rate 10 percent, interest rate 6 percent, taxes 1.5 percent, insurance 0.5 percent, shelter 1 percent - sold at the end of the 4th year.

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Depreciation 10

Beginning value $1000
Ending value 600
Average value 800 (80% of new cost)

ITIS Rate 9% 1/ x 80% New Cost = 7.2 ITI Multiplier
Annual Use Cost rate 17.2

1/ ITIS rate = 6 + 1.5 + 0.5 + 1 = 9 percent.

The calculated average annual fixed cost multiplier and the calculated variable costs of repairs and labor, which are a function of the number of hours of use, are added to give the total cost in the manner described in the following example.

Example: Assume that the total and per acre costs are to be calculated for a given series of operations such as soil preparation, planting and cultivating. If the interest rate is 6 percent, taxes 1.5 percent, insurance 0.5 percent and shelter 1 percent of the remaining value, the ITIS charges are 4.5 percent of the original value (6 + 1.5 + 0.5 + 1 x .5 = 4.5) for machinery kept its expected life. Assume also that the machinery which is required has length of life and price as shown in Table 9. With this data, it is possible to calculate the annual fixed cost of the set of machinery required.

Table 9. Annual fixed cost of different equipment using rule of thumb method.

Machinery	(1) Expected Life (years)	(2) Depreciation a/ rate (%)	(3) ITIS Rate (%)	(4) Fixed Cost (%) 2+3+4	(5) Price ($)	(6) Fixed Cost Per Annum ($) $\frac{4 \times 5}{100} = 6$
Tractor	10	10	4.5	14.5	7,000	1,015.00
Plow	6	16.6	4.5	20.9	1,500	313.50
Disc	8	12.5	4.5	17.0	1,000	170.00
Cultivator	8	12.5	4.5	17.0	700	119.00
Planter	4	25.0	4.5	29.5	1,200	354.00
Stalk Chopper	8	12.5	4.5	17.0	1,000	170.00
					12,400	2,141.50

a/ Depreciation rate is $\frac{100}{\text{expected life in years}}$.*

* If depreciation is calculated from remaining value as shown in Table 3, take loss in value divided by years of use. Example: Tractor beginning of 6th year - value 47.7 percent; loss of value 100 - 47.7 = 52.3 ÷ 5 = 10.46 average annual depreciation.

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Table 10. Repair costs for different equipment and various acreages.

	Machinery							
	Tractor	Plow	Disc	Cultivator	Planter	Stalk chopper	Total operating time	Total repair cost/yr.
Price ($)	7000	1500	1000	700	1200	1000		
Years Life	10	6	8	8	4	8		
Hours per acre a/	1.35	.37	.15	.25	.15	.43		
Acres operated								
100 acres								
Hours	135	37	15	25	15	43	135	
Repairs b/	$ 32	$ 14	$ 3	$ 5	$ 3	$ 13		$ 70
200 acres								
Hours	270	74	30	50	30	86	270	
Repairs b/	$ 91	$ 37	$ 8	$ 12	$ 7	$ 32		$187
300 acres								
Hours	405	111	45	75	45	129	405	
Repairs b/	$162	$ 61	$ 14	$ 20	$ 13	$ 55		$325

a/ From examples given in section entitled "Hours per Acre Rule of Thumb."

b/ Repairs are based on average rates of repair costs as listed in Table 7. For example, a tractor used 405 hours per year for ten years will be used slightly over 4000 hours in ten years. The total repair bill will be $231 per $1000 of list price or $1617 for a $7000 tractor. The average repair cost is $1617 ÷ 10 or $162 per year.

Having calculated the hours of use per year for each piece of equipment the repair cost can be estimated as shown in Table 10. Table 11 shows the total annual and total per acre costs.

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It is quite apparent from Table 11, that the per acre costs decrease markedly as the same machinery is used to operate more acres. Fixed cost of machinery is the same regardless of whether 1 acre or 300 acres are operated, thus by operating a greater acreage, the fixed costs per acre decrease. Therefore, the greater the number of acres operated with a given set of machinery, the lower the per acre cost.

In Figure 1, the decrease in fixed costs per acre with increasing amounts of annual use is demonstrated for a 6-bottom tractor and corn planter.

As the number of acres tilled increases, so the savings associated with increased acreage decrease. For example, increasing the acreage tilled with this tractor from 200 to 300 acres decreases fixed cost per acre from $7.80 to $5.20 - a saving of $2.60. Increasing the acreage tilled from 300 to 400 acres reduces fixed costs by $1.30 and tilling 500 rather than 400 acres reduces fixed cost only $0.80 per acre.

Although least cost can be achieved by using large expensive equipment to capacity, it is often economic to own such equipment when it can be used only to one-fourth to one-half of capacity. Percentage-wise the difference between $0.80 and $2.60 per acre is great but compared to the total cost or total value of an acre of corn it is quite small.

Table 11. Total annual costs and per acre costs for conventional corn growing equipment on various acreages.

Item	Unit	Acres 100	Acres 200	Acres 300
Fixed costs a/	$	2140.50	2140.50	2140.50
Repairs b/	$	70.00	187.00	325.00
Fuel, oil, grease c/	$	116.00	232.00	348.00
Labor	$2/hour	270.00	540.00	810.00
Total Costs	$	2596.00	3099.50	3623.50
Per acre costs	$	25.97	15.50	12.08

a/ See Table 9. b/ See Table 10. c/ See Table 6.

Table 12. Examples of rules of thumb to cover fixed costs of common field equipment.

Machine	Hours annual use	Fixed cost (DITIS)	Repair rate	Total DIRTIS cost	Rounded
Tractor	338	14.5	4.6	20.1	20
Plow	93	20.9	5.4	26.3	25
Disc	38	17.0	1.1	18.1	20
Cultivator	63	17.0	1.8	18.8	20
Planter	38	29.5	1.1	31.3	30
Stalk Chopper	108	17.0	4.2	21.2	20

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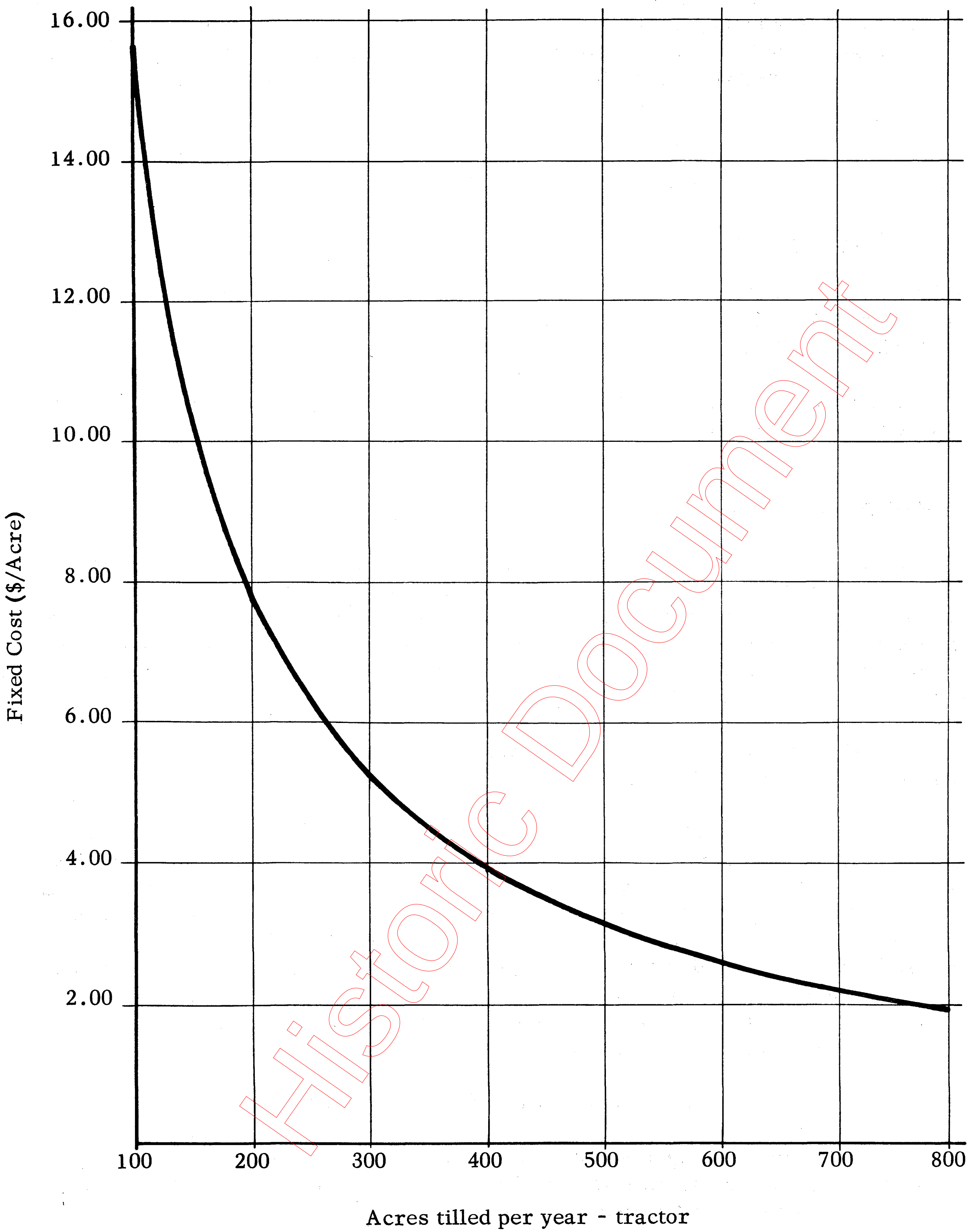
Figure 1. Approximate relationship of per acre fixed cost to amount of annual use for a 6 - plow tractor.



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Personal rules of thumb

Personal rules of thumb can be developed by using the procedures shown in Tables 9 and 10. By combining the fixed cost figures from Table 9 with the appropriate repair cost figures of Table 10, a total machinery cost figure can be derived. This figure does not include the direct operating costs of fuel, oil, grease and labor, which are strictly variable.

Using figures from Table 12, it is easy to calculate the total ownership costs (D-I-R-T-I-S) of farm machinery. Example:

Annual Fixed Cost - (D-I-R-T-I-S)

$9000 tractor at 20 percent = $1800
$2000 plow at 25 percent = 500
$2000 planter at 30 percent = 600

For many decisions, these simple estimates can be quite useful. It is important however, that each person develop a set of guides for his own set of circumstances.

REMAINING VALUE METHOD

Although the rule of thumb method is useful for making quick calculation of approximate ownership costs, ($6,000 tractor x 20 percent = $1200 per year) it should be remembered that the actual ownership costs change as the machinery gets older. The decline in fixed costs is often more rapid than the increase in repair costs and that is why on farms where machines get minimum use, the ownership cost of older machinery is lower.

The first task in this method is the calculation of the depreciation rate using the remaining value method (Table 3).

Next estimate the other fixed costs, for example; interest at 6 percent, taxes at 1.5 percent, insurance at 0.5 percent, and shelter at 1 percent. It should be remembered that these ITIS charges also vary according to individual circumstances. These ITIS rates may be added to give a constant percentage ITIS fixed cost multiplier (for example, 9 percent = 6 + 1.5 + .5 + 1) which is then multiplied by the value remaining at the beginning of the year or the end of the previous year to yield the actual annual ITIS charges. The depreciation cost plus the ITIS cost for the same year gives the annual fixed cost for that year. The sum of the annual costs to date divided by the number of years to date gives the average annual fixed cost.

An example of this method of estimating fixed costs is presented in Table 13.

Using the fixed cost figures from Table 13 and assuming that the variable costs are to be calculated for a tractor used for 500 hours a year with a labor cost of $2 per hour, the total costs are calculated as shown in Table 14.

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Table 13. Tractor fixed cost figures per $1000 value for 10 years.

End of year	Remaining value	Depreciation ($)	ITIS (9%)	Annual cost	Ave. annual cost to date per $1000 list price	Ave. annual cost to date as a % of list price (rounded)
0	1000	---	---	---	---	--
1	630	370	90.00	$460.00	$460.00	46
2	588	42	56.70	98.70	279.35	28
3	548	40	52.92	92.92	217.20	22
4	511	37	49.32	86.32	176.98	18
5	477	34	45.99	79.99	163.58	16
6	445	32	42.93	74.93	148.81	15
7	415	30	40.05	70.05	137.56	14
8	388	27	37.35	64.35	128.41	13
9	362	26	34.92	60.92	120.91	13
10	337	25	32.58	57.58	114.58	11

As discussed in the next section, the decreasing annual total cost method is useful for evaluating when equipment should be traded, and at what cost.

By using remaining value figures shown in Table 3 (or similar data) and repair costs comparable to those shown in Table 7, cost figures similar to those shown in Table 14. can be calculated for most common pieces of equipment for any normal annual use rate.

TRADING MACHINERY

From a machine cost viewpoint, if machinery is getting the job done satisfactorily and on time, it should be used as long as the overhead or fixed costs are decreasing faster than the variable costs are increasing.

When variable repair costs are increasing faster than fixed costs are decreasing, the total costs increase.

During the first year or two, depreciation, interest, taxes and insurance, (DITIS) are high but repair costs are low. As machinery gets older, DITIS charges decline, but repair costs go up. For any piece of equipment, the objective is to find the point at which the combination of these costs is least.

With continuous technological improvement however, the operator is often faced with the dilemma of having equipment which although not worn out, is less efficient than new equipment. From Table 14, it can be seen that the cost of trading a few years earlier than anticipated is not excessive. For example, if the question is to trade when the tractor is 7 years old rather than 10 years old, the additional per annum cost would be $128.95 (1184.32 - 1055.37). This extra cost may amount to less than fifty cents per acre.

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Table 14. Annual average machinery and labor costs per 500 hours annual use per $1000 list cost.

	Per $1000 list price					Example: $7200 Gas Tractor				
	Fixed Costs:		Variable:	Total Mach. Costs		Machine Cost:			Total Cost:	
End of year	Annual ($)	Ave. annual to date ($)	Repairs Costs a/ ($)	Annual ($)	Ave. annual to date ($)	Annual ($)	Ave. annual to date ($)	Operating Cost b/ ($)	Annual ($)	Ave. annual to date ($)
1	460	460	10	470	470.00	3384 c/	3384	1520	4904	4904
2	98.70	279.35	19	117.70	293.85	847.44	2115.72	1520	2367.44	3635.72
3	92.92	217.20	24	116.92	234.87	841.82	1691.06	1520	2361.82	3211.81
4	86.32	184.48	29	115.32	204.99	830.30	1475.93	1520	2350.30	2995.89
5	77.99	163.19	34	111.99	186.37	806.33	1341.86	1520	2326.33	2861.98
6	74.93	148.48	34	108.93	173.48	784.29	1249.05	1520	2304.29	2769.03
7	70.05	137.28	40.50	110.55	164.49	795.96	1184.32	1520	2315.96	2704.30
8	64.35	128.16	40.50	104.85	157.03	754.92	1130.61	1520	2274.92	2650.63
9	60.92	120.76	46.00	106.00	151.36	763.20	1089.79	1520	2283.20	2609.80
10	57.58	114.44	46.00	103.58	146.58	745.77	1055.37	1520	2265.77	2575.40

a/ Repair costs are taken from Table 6. The repair cost for each additional 500 hours of use is calculated to give an increasing repair cost over time. If the tractor was only used 100 hours a year the repair cost would be $2 per year per $1000 list for the first five years and $3.75 per $1000 for the next five years, giving a total of $29 per $1000 list for a total of 1000 hours of use.

b/ Operating fuel costs calculated as in Table 6 (.79 x 7.2 x .18 = $1.04/hour). Labor costs $2 per hour. Total operating costs per hour = $3.04.

c/ $\frac{\$470}{\$1000} \times \$7200 = \$3384$; $\frac{\$117.70}{\$1000.00} \times \$7200 = \$847.44$; et cetera.

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When compared to the increased potential and reduced risk of break-down time with new equipment, or when new efficiencies are considered, the cost of early trading may be justified.

The question of when to trade is really one of judgment and is one which must be made by each operator according to his own circumstances. Thus when the operator decides that the cost of trading (calculated as shown above) is less than losses that he will incur through machine break-down or due to obsolescence (a new machine would do a better job), he should trade. He might decide that new machinery would give him more leisure time or more satisfaction, and he would be prepared to pay more for such satisfaction.

Operators with different sized operations and different financial situations might view the question of trading in a different light. The large operator, with more to lose from breakdown time in critical periods, might wish to trade in the third or fourth year by which time he has gained a substantial amount of the economies (relatively stable average annual cost). The intermediate size operator, on the other hand, might prefer to keep his machinery longer, till it has reached the lowest average annual cost. This man might decide to trade earlier if he has had a good year and wishes to take the tax advantage of machinery purchases. The small operator with limited finances and surplus labor might find that it is to his advantage to purchase used equipment, repair it, and run it till the end of its useful life.

HOW BIG SHOULD EQUIPMENT BE?

Since maximum corn yields can only be achieved by planting within about 20 days in the spring (approximately May 1 till May 20 in Central Indiana) and weather and soil conditions are usually suitable for planting during only about half this period, the maximum hours of use of a corn planter would be about 150 hours. As shown in Figure 1, most of the efficiencies associated with volume of use are achieved with about 300 to 400 acres for a tractor.

Since operating costs and labor charges must be added to fixed costs, a fairly large decrease in fixed costs has only a relatively minor effect on total cost.

Most of the efficiencies of tractors can be gained with 500 to 600 hours use per year, but often their acquisition can be justified with only 100 to 200 hours of use.

Since different sets of machinery obviously have different total costs, the question which may be asked is, "what size of machinery is best?"

Because output is more important than cost, this question must be answered in the context of total profits. Machinery must be big enough to get the job done correctly, on time, and in large volume.

The day of cheap labor is over in agriculture. Unskilled, incompetent labor has little place in modern farming. This means that wages of hired workers must be competitive with nonfarm wages and that earning opportunities of operators must, over time,

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be competitive with earnings in other businesses. To be competitive, farmers must use the biggest equipment available to them on a practical basis. The question is not how big should equipment be, but rather how much land must I have to justify the use of big equipment?

Figures 2 and 3 show the per acre costs for various sized machinery systems, when labor costs $2 per hour and $5 per hour, respectively. When labor is charged at $2 per hour (Figure 2) there is little difference in per acre costs between the various sizes of equipment and different tillage systems. When labor is charged at five dollars per hour (Figure 3) it is apparent that lower per acre costs are achieved by the use of bigger machinery even with volume as small as 100 acres. Although effect on yield is very important, no effort is made here to compare the output of different systems. It should be noted though that the bush-hog system of reduced tillage is the least cost system. Conclusive evidence on the crop yields achieved with this system is not yet available, but since it does offer such a low cost alternative, its development should be closely watched.

Size of machinery

In selecting the optimum size of equipment to be used, the following considerations should be kept in mind:

(1) The smallest equipment that will do the job usually costs less than bigger equipment but because of the importance of volume and timeliness it may not be the most profitable.

(2) The number of hours available in which field work can be done in a timely fashion are quite limited, and most of the economies associated with volume of use can be gained when machinery is used at much less than full capacity. Therefore, it is often practical to use big expensive equipment at less than full capacity rather than use small equipment.

(3) Trends toward larger farms and specialization are making bigger machines more practical. The three- and four-bottom rigs are in the process of becoming obsolete. Bigger equipment will be necessary if labor in agriculture is to earn as much as might be earned from non-farm jobs in the future.

(4) Big operators do not fear fixed costs because they can be spread over many units. Small operators do not fear variable costs because they do not have to be multiplied by many units. Big operators can stand high depreciation but fear repair costs, but for small operators the reverse is true. (See Figure 3.)

(5) The question is not so much "What size equipment fits my farm?" but "How can I gain the efficiencies of big equipment?"

- Large operators, with strong finances and in high tax brackets tend to buy new and trade frequently.

- Medium size operators tend to buy new equipment and use it several years.

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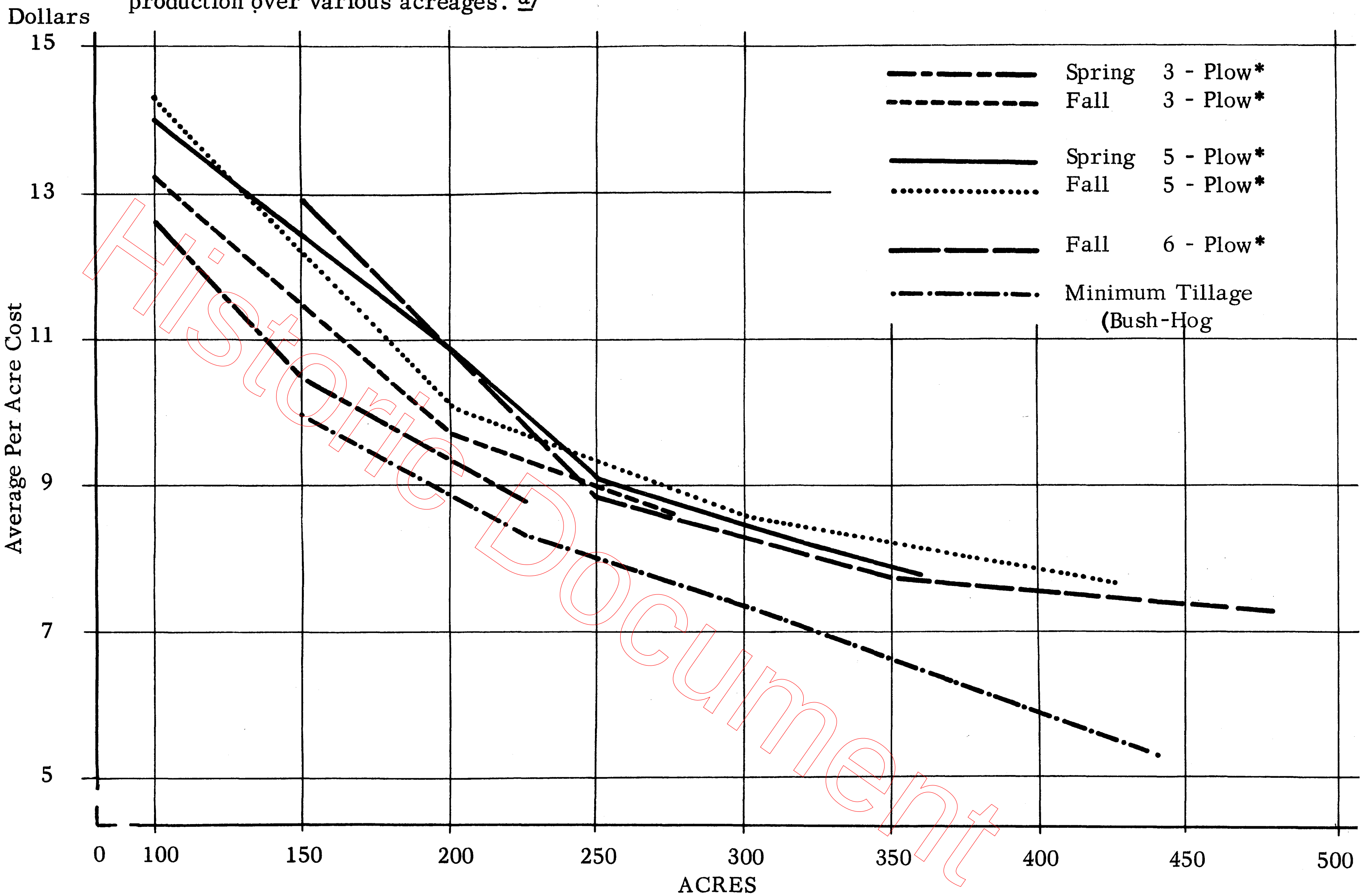
Figure 2. Average per acre costs for labor ($2/hour), machinery and equipment for specified systems of corn production over various acreages. a/



a/ Does not include fuel costs. *Includes stalk chopping, plowing, planting and cultivating.

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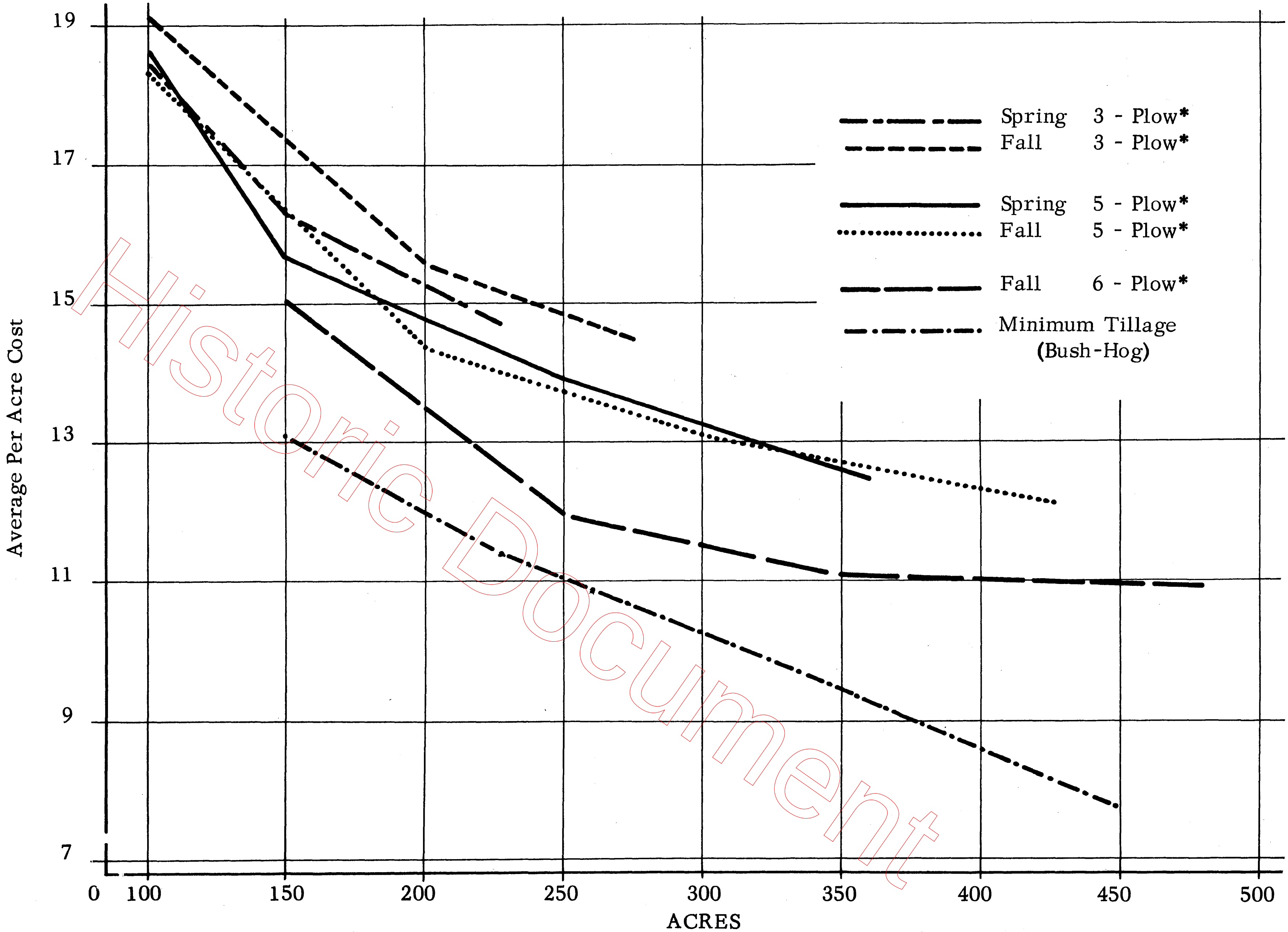
Figure 3. Average per acre costs for labor ($5/hour), machinery and equipment for specified systems of corn production over various acreages. a/



a/ Does not include fuel costs. *Includes stalk chopping, plowing, planting and cultivating.

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- Small operators tend to buy used equipment and finish wearing it out.
- Still smaller operators use custom work.

CUSTOM HIRING

This may be considered as an alternative method of gaining the use of big equipment. In this case, the direct costs are readily available and may be compared with the costs of owning machinery. However, particularly in the case of custom hiring, the question should be asked as to whether the conditions of timeliness and thoroughness would be met. Would yield expectations be as great as they would if the operator did the job himself?

SELECTION OF A MACHINERY SYSTEM

When selecting a machinery system, the farmer should consider more than the cost of getting the job done. He should take into account the method of operation and consider timeliness which would enable him to maximize output.

Timeliness

It is a well-known fact that an optimum period of the year exists during which corn should be planted. Corn planted either before or after this date will be lower yielding. A similar relationship exists during the harvesting process when field losses tend to increase as the season progresses. Table 15 shows the effect of timeliness of planting on yield for two corn hybrids, and Table 16 shows how field losses change with length of the harvest period. For the farmer who is selecting a machinery system, such timeliness factors should be taken into account.

Table 15. Yields for two corn hybrids planted at different times in Central Indiana. a/

Week Beginning	Unit	Hybrid A	Hybrid B
April 19	Bu./Acre	102	124
April 26	Bu./Acre	122	147
May 3	Bu./Acre	149	129
May 10	Bu./Acre	151	117
May 17	Bu./Acre	140	112
May 24	Bu./Acre	124	111

a/ Source: J. A. Groenewald, Ph.D. Thesis, Purdue University

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Table 16. Percent field losses with combine at various lengths of harvest and beginning moisture contents. a/

No. days of harvest	Moisture at beginning of harvest 30%	28%	26%	24%	22%	20%
			Percent loss			
10	3.0	2.6	2.6	2.7	3.2	4.6
20	2.8	2.8	3.0	3.4	4.0	5.4
30	3.2	3.3	3.6	4.1	4.8	6.6
40	3.8	3.9	4.4	5.0	5.8	7.8

a/ Underlined figures indicate the moisture content at the beginning of harvest when field losses will be at a minimum. For example, with a 10-day harvesting period, field losses will be 2.6 percent if harvesting commences when moisture content is 26 - 28 percent.

In the preceding pages, various aspects of costs have been analyzed. These concepts are important tools to use when budgeting alternative machinery systems. While it is convenient and useful to emphasize cost relationships, it should be remembered that the ultimate criteria for decision-making is profit (monetary and/or pleasure). Therefore, any comparisons of alternative systems should consider differences in returns as well as differences in costs.

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