UNIVERSITY OF MINNESOTA
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TRACTOR COSTS AND RATES OF PERFORMANCE

A preliminary report of data secured in 1939 covering the cost of operation and the rate of performance on farm tractors in Minnesota

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Source of Data

Cost and performance data covering 42 tractors operated on 33 farms in 1939 have been submitted to the Minnesota Agricultural Experiment Station. The distribution of these tractors by make and model is as follows: McCormick Deering F-20, 6; McCormick Deering F-12, 5; McCormick Deering F-14, 3; McCormick Deering WK-40, 1; McCormick Deering 22-36, 1; McCormick Deering F-30, 1; John Deere A, 5; John Deere D, 2; John Deere GP, 2; John Deere B, 2; Allis Chalmers W-C, 5; Allis Chalmers B, 3; Allis Chalmers U, 1; Case L, 1; Case CC, 1; Caterpillar 30, 1; Minneapolis Moline MTA, 1; and Oliver 70, 1. Twelve of these tractors were of the standard type and 29 of the all-purpose type. Twenty-nine were equipped with rubber tires. The average age of these tractors was 4 years. Two had been in use only one year, and five, ten years or more. The average estimate of the operators as to the total life of their tractor was 11½ years and of the rubber tires, 7½ years.

The drawbar horse power of these tractors as indicated by the University of Nebraska tests varied from 9.28 to 28.34. In order to make comparisons within comparable size groups and between groups, all tractors were divided in 4 groups based on the official Nebraska ratings. The drawbar horse power ratings of each group was as follows: Group I, 5.50 to 11.99; Group II, 11.00 to 18.49; Group III, 18.50 to 24.99; and Group IV, 25.00 to 31.49. The average drawbar horse power ratings of these groups were: Group I, 10.0; Group II, 16.3; Group III, 21.4; and Group IV, 26.4. The average size of the farms was 300 acres and the range was from 40 to 800 acres. Ten farms were under 200 acres in size, 13 were from 200 to 320 acres, and 10 were over 320 acres. The average size of the 9 farms on which 2 tractors were used was 411 acres. On three farms no horses were maintained. On the other 30 farms the average number of work horses was 4.7 per farm and of colts, 1.4.

Cost of Tractor Operation

The average cost per hour of operating the tractors in each size group is shown in Table 1. Fuel and lubricants are charged at the purchase price. Man labor spent in servicing and repairing is charged at 25 cents per hour. Annual depreciation is computed by dividing the purchase price of the tractor by the farmer's estimate of the number of years it will last. Interest is charged at 5 per cent of the average value of the tractor in 1939.

The average cost of operating the tractors in each size group is shown. There was, however, a wide range in costs among the tractors in each group. The range in total cost per hour and in hours worked annually is shown in Table 1. One of the important factors affecting costs per hour is the number of hours a tractor is used annually. This is indicated in Table 2. The operating cost per hour is fairly constant but fixed charged decrease as the hours of annual use increase.

The fuel cost per hour varied widely among tractor in the same size group. The amount of fuel used per 100 hours varied from 63 to 126 gallons for Group I; from 121 to 240 for Group II, from 186 to 256 gallons for Group III, and from 269 to 337 gallons for Group IV. The variation in quantity of fuel was in part the result of differences in the degree to which the full capacity of the tractor was utilized.

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Table 1.
Average Cost per Hour of Operating Tractors by Size Groups

Size Group	I	II	III	IV
Drawbar horse power	5.50 - 11.99	12.00 - 18.49	18.50 - 24.99	25.00 - 31.49
Number tractors	13	20	5	4
Operating costs				
Fuel	$.120	$.185	$.213	$.348
Lubricants	.021	.022	.029	.048
Labor	.014	.016	.019	.023
Cash repairs	.026	.042	.055	.135
Total	.181	.265	.316	.554
Fixed charges				
Depreciation	.178	.166	.161	.366
Interest at 6% on avg. value	.085	.076	.069	.128
Total	.263	.242	.230	.494
Total cost per hour	$.444	$.507	$.546	$1.048
Range in cost per hour	.320 - .713	.347 - .734	.485 - .679	.654 - 1.188
Hours of work per year	458	720	649	340
Range in hours of work	216 - 858	297 - 1787	437 - 858	184 - 627
Labor & Materials per 100 hours				
Servicing, hours	4.4	5.0	4.1	6.0
Repairing, hours	1.2	2.5	3.8	3.9
Fuel, gasoline, gal.	85	91	129	313
distillate, gal.	18	78	93	1
kerosene, gal.	-	1	-	-
Total	103	170	222	314
Cylinder oil, gal.	2.8	3.3	4.7	6.2

and in part due to efficiency in the use of fuel. Differences in the kind of fuel and in the price paid for it caused considerable variation in cost. In 28 tractors gasoline was used exclusively, in 13 distillate was used except in starting, and in another both gasoline and distillate were used. Only 2 operators reported using any kerosene. The average price of gasoline reported was 13 cents and of distillate 9 cents. There was, however, a range of from 9.9 to 18.2 cents in the price reported paid for gasoline and of from 7.7 to 10.1 cents in the price paid for distillate. The average fuel cost per gallon for all tractors varied from 8 to 16 cents. These price differences caused considerable variation in fuel costs among different tractors. There was also a large variation in repair costs since some tractors may require very little repairs in a particular year while others may need a complete overhauling.

Table 2.
Effect of Annual Hours of Use on Cost per Hour for Group II Tractors

	Under 500 hrs.	500-800 hrs.	Over 800 hrs.
Number tractors	5	8	7
Operating costs, cents per hr.	28.5	28.2	22.1
Fixed charges, cents per hr.	33.9	23.2	16.8
Total	62.4	51.4	38.9
Operating costs, % of total	46	55	57
Fixed charges, % of total	54	45	43

Amount and Kind of Work Done by Tractors

The average hours of annual use per tractor in 1939 was 594. The average and range for each size group are shown in Table 1. One farmer used his tractor only 184 hours in 1939 whereas another used his 1787 hours. Most of the tractors were used for both belt and drawbar work. The distribution of total tractor hours in 1939 into these two classes is shown in Table 3. The smaller tractors were used largely on the home farm whereas the operators of the large tractors used them to a considerable extent for custom work. The small tractors were used largely for drawbar work but belt work represented a relatively large proportion of the work for which the large tractors were used.

Table 3.
Distribution of Annual Hours of Work per Tractor

Group	Home Work			Custom Work			All Work		
	Drawbar	Belt	Total	Drawbar	Belt	Total	Drawbar	Belt	Total
				Hours					
I	382	26	408	20	30	50	402	56	458
II	620	47	667	38	15	53	658	62	720
III	438	98	536	19	94	113	457	192	649
IV	181	63	244	10	86	96	191	149	340
Avg. all	483	48	531	27	36	63	510	84	594
				Percentages					
I	83.3	5.7	89.0	4.4	6.6	11.0	87.8	12.2	100.0
II	86.1	6.5	92.6	5.3	2.1	7.4	91.4	8.6	100.0
III	67.5	15.1	82.6	2.9	14.5	17.4	70.4	29.6	100.0
IV	53.3	18.5	71.8	2.9	25.3	28.2	56.2	43.8	100.0
Avg. all	81.3	8.1	89.4	4.5	6.1	10.6	85.8	14.2	100.0

One of the advantages of tractor power over animal power is the fact that the tractor can be used continuously for 24 hours a day if necessary. However, the farmers supplying the information on which this report is based seldom put in long

work days with their tractors. The average hours of tractor use per day was 5.4 hours per tractor for the days they were actually in use. On only 10 per cent of the days on which the tractors were in use were they operated 10 or more hours per day. These facts are shown in Table 4.

Table 4.
Number of Days Tractors are Operated and Hours of Tractor Work per Day

Group	Under 2 hrs.	2-3¾ hrs.	4-5¾ hrs.	6-7¾ hrs.	8-9¾ hrs.	10 hours and over	Total days operated	Average hours per day
I	18	20	17	14	10	9	88	5.2
II	16	26	25	24	21	14	126	5.7
III	23	30	20	25	18	11	127	5.1
IV	8	16	15	12	11	4	66	5.3
Avg. all	16	24	21	20	16	11	108	5.4
				Per Cent Distribution				
I	20	23	19	16	12	10		
II	12	21	20	19	17	11		
III	18	23	16	20	14	9		
IV	13	24	22	18	17	6		
Avg. all	15	22	20	18	15	10		

The specific types of operations for which the different types of tractors were used are shown in Table 5. The use of the large tractors for drawbar opera-

Table 5.
Percentage Distribution of Hours of Tractor Use by Size Groups

	Tractor Size Groups				Average all tractors
	I %	II %	III %	IV %	
Plowing and preparing seedbed*	43.2	44.4	44.4	53.2	44.6
Seeding**	5.1	3.4	5.2	-	3.9
Cultivating row crops	17.1	15.5	-	-	13.1
Harvesting crops***	15.8	25.3	15.9	-	20.3
Miscellaneous	6.7	2.8	4.7	3.0	4.0
Total drawbar	87.9	91.4	70.2	56.2	85.9
Threshing, filling silo and corn shredding	.7	4.8	15.4	27.6	6.6
Grinding feed	1.5	2.5	5.3	5.7	2.8
Miscellaneous	9.9	1.3	9.1	10.5	4.7
Total belt	12.1	8.6	29.8	43.8	14.1

*Includes in addition to plowing chiefly disking, springtooth-harrowing, spike-tooth-harrowing and field cultivating.
**Includes seeding of small grains and row crops.
***Includes hay, grain, and corn harvest.

tions were confined largely to plowing and seedbed preparation. These represent the type of work at which large power units can be used advantageously. For many of the seeding, cultivating, and harvesting operations it is impracticable to use implements large enough to utilize the full power of the large tractors.

A comparison of the hours of use for tractors of different types or differently equipped is shown in Table 6. Tractors with steel wheels are used relatively more for belt than for drawbar work. The same is true of the standard type of tractor as compared with the all-purpose type. The standard type of tractors is used only to a limited extent for cultivating row crops, but this operation constitutes over 15 per cent of all the work done by the all-purpose tractors as measured in terms of hours of work.

Table 6.
Percentage Distribution of Hours of Tractor Use by Types of Tractors

	Types of Tractors			
	Tractors with		All-purpose type	Standard type
	Rubber tires	Steel wheels		
	%	%	%	%
Plowing and seedbed preparation*	42.2	51.9	43.6	43.5
Seeding**	4.6	1.5	4.1	3.2
Cultivating row crops	13.6	11.1	15.6	3.9
Harvesting crops***	23.5	10.7	19.6	14.0
Miscellaneous	4.9	1.6	6.9	7.1
Total drawbar	88.8	76.8	89.8	71.7
Threshing, filling silo, and shredding corn	3.9	14.4	3.7	16.6
Grinding feed	2.7	3.3	2.6	3.6
Miscellaneous	4.6	5.5	3.9	8.1
Total belt	11.2	23.2	10.2	28.3

*Includes in addition to plowing chiefly disking, springtooth-harrowing spike-tooth-harrowing and field cultivating.
**Includes seeding of small grains and row crops.
***Includes hay, grain, and corn harvest.

Rate of Tractor Performance

The average rate of accomplishment per hour for each size group by operations is shown in Table 7. For some operations, such as plowing and seedbed preparation at which the tractor is likely to be loaded fairly near to its capacity, the accomplishment increases with the size of the tractor. For such operations as planting corn or cutting corn where the size of implement was too small to need more power than that furnished by tractors in the smallest size group, the rate of performance did not increase with the size of the tractor. Tractors in the largest size group were not generally used for the lighter operations where it was difficult to utilize their full capacity.

Table 7.
Rate of Tractor Accomplishment per Hour for Specific Operations

	Unit of accomplishment	Size Group I	II	III	IV
Plowing	Acre	.58	.82	1.19	1.33
Disking	"	2.58	3.82	5.62	7.96
Springtooth-harrowing	"	2.58	2.95	-	4.20
Field cultivating	"	2.17	2.99	3.79	-
Spiketooth-harrowing	"	6.17	8.54	10.10	-
Seeding small grain	"	2.24	3.98	3.62	-
Planting corn	"	2.32	2.50	2.05	-
Cultivating corn	"	1.79	2.36	-	-
Mowing hay	"	1.97	2.38	-	-
Raking hay	"	2.34	2.48	3.00	-
Harvesting grain (binder)	"	1.84	2.26	2.62	-
Windrowing grain	"	-	3.49	-	-
Harvesting grain (combine)	"	.90	1.40	1.84	-
Cutting corn	"	.82	.86	.65	-
Picking corn	"	.89	1.03	1.09	-
Grinding feed	Lb.	1200	2259	2828	2348
Threshing grain	Bu.	-	84	115	128
Shelling corn	Bu.	51	102	178	275
Filling silo	Ton	-	6.2	11.9	8.7

The rate of accomplishment is closely related to the size of implement used. The number of acres covered per hour with machines of different sizes or widths is shown in Table 8. The size of implement, is in general proportional to the size of tractor. However, there is considerable variation in individual cases. Plows varied within the different tractor size groups as follows: Group I, one 16-inch bottom to two 14-inch bottoms; Group II and Group III, two 14-inch bottoms to three 16-inch bottoms; and Group IV, three 14-inch bottoms to five 14-inch bottoms. Since speed as well as size of implement affects the rate of accomplishment, a tractor pulling a two-bottom plow at high speed may plow as much land in an hour as another tractor drawing a three-bottom plow but operated at a slower speed. For this reason, there was considerable variation in the rate of operation of different machines. Some farmers secured a capacity load for their tractors by using larger implements whereas others used smaller machines but operated at a higher speed. In many cases a full load was secured for the larger tractors by pulling two implements at one time, such as a plow and a harrow, or a disk and a packer. No rate of performance is shown for these mixed operations. The data in Table 7 and Table 8 cover only cases where but one kind of implement is used at a time.

Table 8.
Acres Covered per Hour with Implements of Different Sizes

Plowing

1-16" bottom	.40 acres		3-14" bottoms	1.05 acres	
1-18" "	.45 "		3-16" "	1.20 "	
2-14" "	.70 "		4-16" "	1.59 "	
2-16" "	.80 "		4-14" "	1.74 "	

Disking

7'	2.08 acres	12'	3.56 acres	16'	4.75 acres
8'	2.38 "	13'	3.86 "	18'	5.35 "
9'	2.67 "	14'	4.16 "	20'	5.94 "
10'	2.97 "	15'	4.46 "	21'	6.24 "
11'	3.27 "				

Springtooth-Harrowing

6'	2.01 acres	8'	2.68 acres	10'	3.35 acres
7'	2.35 "	8½'	2.85 "	11'	3.69 "
7½'	2.51 "	9'	3.01 "		

Field Cultivating

7'	2.25 acres	8'	2.57 acres	10'	3.22 acres
7½'	2.41 "	8½'	2.73 "	11½'	3.54 "

Spiketooth-Harrowing

10'	3.77 acres	20'	7.53 acres	24'	9.04 acres
12'	4.52 "	22'	8.28 "	25'	9.41 "
13½'	5.08 "	23'	8.66 "	26'	9.79 "
16'	6.03 "				

Seeding Small Grain

7'	2.22 acres	10'	3.17 acres	12'	3.81 acres
8'	2.54 "	11'	3.49 "	14'	4.44 "

Planting Corn

2 row	1.48 acres	3 row	2.22 acres	4 row	2.97 acres

Cultivating Corn

1 row	1.15 acres	2 row	2.30 acres	3 row	3.45 acres

Mowing Grain

5'	1.89 acres	6'	2.26 acres	7'	2.74 acres

Table 8.
Acres Covered per Hour with Implements of Different Sizes
(continued)

Harvesting Grain - Binder					
7'	1.68 acres	8'	1.92 acres	10'	2.40 acres
Harvesting Corn - Binder					
		1 row	.82 acres		
Picking Corn					
One-row	.65 acres			Two-row	1.30 acres