UNIVERSITY OF MINNESOTA
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TRACTOR COSTS AND RATES OF PERFORMANCE

A preliminary report of data secured in 1940 covering
the cost of operation and the rate of performance
on farm tractors in Minnesota

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Source of Data

Costs and performance data covering 32 tractors operated on 24 farms in 1940 have been submitted to the Minnesota Agricultural Experiment Station. The distribution of these tractors by make and model is as follows: McCormick Deering F-12, 4; McCormick Deering F-14, 1; McCormick Deering F-20, 2; McCormick Deering F-30, 1; McCormick Deering 15-30, 1; McCormick Deering H, 3; McCormick Deering M, 3; John Deere A, 3; John Deere B, 2; John Deere GP, 2; Allis Chalmers B, 3; Allis Chalmers W-C, 3; Allis Chalmers U, 1; Case CC, 1; Case L, 1; Oliver 70, 1; six of these tractors were of standard type and twenty-six of the all-purpose type. Twenty-five were equipped with rubber tires. The average age of the tractors was 4.5 years. Four had been used less than one year, two one year, five two years, twelve three or four years, eight five to ten years, and two over ten years. The average estimate of the operators as to the total life of their tractor was eleven years and of the rubber tires, 8 years.

The drawbar horsepower of these tractors as indicated by the University of Nebraska tests varied from 9.28 to 28.34. In order to make comparison within comparable size groups and between groups, all tractors were divided in 4 groups based on the official Nebraska ratings. The drawbar horsepower 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 horsepower ratings of these groups were: Group I, 9.9; Group II, 15.6; Group III, 19.5; and Group IV, 36.8. The average size of the farms was 272 acres and the range was from 40 to 535 acres. Eight farms were under 200 acres in size, 9 were from 200 to 320 acres, and 7 were over 320 acres. The average size of the 7 farms on which 2 tractors were used was 365 acres. On three farms no horses were maintained. On the other 21 farms the average number of work horses was 4.5 per farm and of colts, .8.

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 6 per cent of the average value of the tractor in 1940.

The fuel cost per hour varied widely among tractors in the same size group. The amount of fuel used per 100 hours varied from 69 to 157 gallons for Group I, from 130 to 230 for Group II, from 176 to 192 gallons for Group III, and from 211 to 358 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 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 16 tractors gasoline was used exclusively, in 8 distillate was used except in starting, and in 2 both gasoline and distillate were used. Only one operator reported using any kerosene. The average price of gasoline reported was 13.5 cents and of distillate 8.7 cents. There was, however, a range of from 10.0 to 16.5 cents in the price reported paid for gasoline and of from 7.8 to 10 cents in the price paid for distillate. The average fuel cost per gallon varied from 8 to 16 cents among these tractors. These price differences caused considerable variation

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Table 1
Average Cost Per Hour of Operating Tractors by Size Groups

Size group	I	II	III	IV
Drawbar horsepower	5.50 - 11.99	12.00 - 18.49	18.50 - 24.99	25.00 - 31.49
Number tractors	9	12	2	3
Operating costs				
Fuel	$.130	$.183	$.219	$.294
Lubricants	.029	.018	.031	.027
Labor	.010	.010	.016	.029
Cash repairs	.019	.039	.072	.036
Total	.188	.250	.338	.386
Fixed charges				
Depreciation	.142	.184	.275	.321
Interest at 6% on average value	.078	.074	.167	.127
Total	.220	.258	.442	.448
Total cost per hour	.408	.508	.780	.834
Range in cost per hour	.273 - .491	.303 - .814	.616 - .943	.484 - 1.108
Hours of work per year	485	643	306	364
Range in hours of work	287 - 738	387 - 921	197 - 414	185 - 696
Labor & materials per 100 hours				
Servicing, hours	3.9	3.3	2.9	6.7
Repairing, hours	.3	.9	3.3	4.6
Fuel, gasoline, gal.	78.6	72.3	183.9	293.2
distillate, gal.	26.9	97.0	-	-
kerosene, gal.	-	.6	-	-
Total	105.5	169.9	183.9	293.2
Cylinder oil, gal.	4.1	2.7	3.9	3.7
Grease, lbs.	3.1	.7	-	1.0

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.

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 cost 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 charges decrease as the hours of annual use increase.

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

	Under 500 hrs.	500-700 hrs.	Over 700 hrs.
Number of tractors	2	5	5
Operating costs, cents per hour	33.3	23.8	22.9
Fixed charges, cents per hour	44.0	26.3	18.0
Total	77.3	50.1	40.9
Operating costs, % of total	43	48	56
Fixed charges, % of total	57	52	44

Amount and Kind of Work Done by Tractors

The average hours of use per tractor in 1940 was 530. The average and range for each size group are shown in table 1. One farmer used his tractor only 197 hours in 1940 whereas another used his 921 hours. Most of the tractors were used for both belt and drawbar work. The distribution of total tractor hours in 1940 into these two classes is shown in table 3. The smaller tractors were used somewhat more for custom work than were the larger ones. Belt work represented a relatively larger proportion of the work for which the tractors in Group IV 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	390	33	423	61	2	63	451	35	486
II	525	50	575	50	17	67	575	67	642
III	216	23	239	8	-	8	224	23	247
IV	286	46	332	-	8	8	286	54	340
Avg. all	354	38	392	29	7	36	384	44	428
				Percentages					
I	80.2	6.8	87.0	12.7	.3	13.0	92.8	7.2	100.0
II	81.8	7.8	89.6	7.8	2.6	10.4	89.6	10.4	100.0
III	87.5	9.3	96.8	3.2	.0	3.2	90.7	9.3	100.0
IV	84.1	13.5	97.6	.0	2.4	2.4	84.1	15.9	100.0
Avg. all	83.4	9.3	92.7	6.0	1.3	7.3	89.3	10.7	100.0

One of the advantages of tractor power over animal power is the fact that the tractor can be used continuously for nearly 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 5.3 hours per tractor for the days they were actually in use. On only 8 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. Tractors in Group I and II were used more days per year than were those in Groups III and IV.

Table 4

Number of Days Tractors Are Operated and Hours of Tractor Work Per Day

Group	Under 2 hrs.	2-3 3/4 hrs.	4-5 3/4 hrs.	6-7 3/4 hrs.	8-9 3/4 hrs.	10 hours and over	Total days operated	Av. hrs. per day
I	26	20	16	16	15	10	103	4.7
II	17	26	20	25	18	12	118	5.5
III	11	12	8	10	8	3	52	5.9
IV	17	20	12	8	10	4	71	5.1
Avg. all	17	20	14	15	13	7	86	5.3
				Per Cent Distribution				
I	25	19	15	15	14	10		
II	14	22	17	21	15	10		
III	21	23	15	19	15	06		
IV	24	28	17	11	14	06		
Avg. all	21	23	16	17	15	8		

The distribution of tractor work by months for drawbar and belt work by size groups is shown in table 5. More than half of the b lt work done with the small tractors is performed in March and April. This is largely feed grinding. Most of the beltwork for which the large tractors are used is threshing and silo filling. These operations are performed in July and August. Drawbar work is distributed through the months from April to October inclusive with little being done the rest of the year.

Table 5

Percentage Distribution of Tractor Work by Month and Size Groups

	Group I 10 tractors			Group II 12 tractors			Groups III & IV 10 tractors		
	Belt	Drawbar	Total	Belt	Drawbar	Total	Belt	Drawbar	Total
January	6.1	.4	.9	3.5	.1	.4	8.7	.1	1.2
February	8.3	.6	1.2	4.5	.1	.5	9.3	.3	1.5
March	19.8	.7	2.1	4.5	.1	.5	6.2	.1	.8
April	30.4	11.9	13.3	3.7	12.2	11.4	1.5	17.4	15.4
May	3.8	18.8	17.6	3.2	16.3	15.0	1.5	18.1	15.9
June	1.3	14.9	13.9	2.7	14.8	13.6	2.0	10.0	9.0
July	2.2	20.0	18.7	4.5	16.8	15.6	3.8	17.3	15.5
August	6.3	8.2	8.0	41.2	8.2	11.4	24.4	9.4	11.4
September	3.8	13.5	12.8	15.8	12.2	12.6	27.6	8.5	11.0
October	8.1	8.0	8.0	7.2	15.1	14.3	4.4	14.3	13.0
November	3.8	.3	.6	6.1	.2	.9	7.8	.1	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The monthly distribution of all tractor work divided into belt and drawbar work and into custom and home work is shown in table 6. Threshing and silo filling are the principal custom operations, and this work is performed in August and September. Custom drawbar work is largely done during the months from June to October inclusive. Only 7 per cent of all tractor work is done from November 1 to the end of March. This is largely belt work such as feed grinding and wood sawing.

Table 6
Percentage Distribution of Tractor by Months

	Custom			Home			Total work		
	Belt	Drawbar	Total	Belt	Drawbar	Total	Belt	Drawbar	Total
January	.3	.4	.4	6.8	.2	.8	5.5	.2	.7
February	2.2	-	.4	7.9	.3	.9	6.6	.2	.9
March	4.4	.1	1.0	9.5	.3	1.1	8.5	.3	1.0
April	2.2	4.6	4.2	11.3	14.0	13.8	9.3	13.1	12.7
May	.4	6.3	5.2	3.6	18.6	17.3	2.9	17.4	16.0
June	.3	14.9	12.0	2.6	13.9	12.9	2.2	14.0	12.8
July	-	23.3	18.8	4.8	17.3	16.3	3.8	17.9	16.6
August	57.4	10.5	19.5	20.9	8.2	9.2	28.7	8.4	10.4
September	25.2	10.8	13.6	13.6	12.1	12.2	16.0	12.0	12.4
October	1.3	20.6	16.8	8.2	11.8	11.5	6.7	12.7	12.1
November	3.8	8.0	7.2	3.8	3.1	3.2	3.8	3.6	3.6
December	2.5	.5	.9	7.0	.2	.8	6.0	.2	.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The specific types of operations for which the different types of tractors were used are shown in table 7. For cultivating, it is impracticable to use implements large enough to utilize the full power of the Group IV tractors.

Table 7
Percentage Distribution of Hours of Tractor Use by Size Groups

	Tractor size groups				Average all tractors
	I %	II %	III %	IV %	
Plowing and preparing seedbed*	43.4	34.8	55.4	39.0	43.1
Seeding**	3.1	5.2	4.0	5.8	4.6
Cultivating row crops	15.2	14.3	13.2	7.8	12.6
Harvesting crops***	17.1	25.5	13.3	20.1	19.0
Miscellaneous	14.7	10.9	4.6	11.5	10.4
Threshing, filling silo, and corn shredding	-	5.8	2.9	9.9	6.2
Grinding feed	2.3	3.4	4.1	4.8	3.5
Miscellaneous	4.2	.1	2.5	1.1	1.6
	6.5	9.3	9.5	15.8	10.3

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

A comparison of the hours of use for tractors of different types or differently equipped is shown in table 8. 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 16 per cent of all the work done by the all-purpose tractors as measured in terms of hours of work.

Table 8

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*	36.6	56.0	44.4	34.1
Seeding**	5.0	2.2	3.1	2.9
Cultivating row crops	14.0	12.1	15.8	8.8
Harvesting crops***	25.5	12.6	21.9	19.1
Miscellaneous	7.1	.7	6.6	14.3
Total drawbar	88.2	83.6	91.8	79.2
Threshing, filling silo, and shredding corn	2.6	10.0	2.7	10.4
Grinding feed	3.2	3.8	2.8	5.3
Miscellaneous	6.0	2.6	2.7	5.1
Total belt	11.8	16.4	8.2	20.8

*Includes in addition to plowing chiefly disking, springtooth-harrowing, spiketooth-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 9. 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 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 9
Rate of Tractor Accomplishment Per Hour for Specific Operations

	Unit of accomplishment	Size group I	II	III	IV
Plowing	Acre	.59	.91	.97	1.24
Disking	"	2.38	3.78	3.68	6.64
Springtooth-harrowing	"	1.89	2.13	2.53	4.51
Field cultivating	"	1.61	3.25	4.16	3.64
Spiketooth-harrowing	"	6.16	8.09	7.22	3.38
Seeding small grain	"	2.31	3.50	2.39	5.80
Planting corn	"	1.93	3.45	-	-
Cultivating corn	"	1.69	2.62	1.67	2.55
Mowing hay	"	1.38	3.25	-	3.03
Raking hay	"	2.04	2.19	1.94	3.66
Harvesting grain (binder)	"	1.61	2.23	1.68	1.64
Windrowing grain	"	-	1.84	-	3.91
Harvesting grain (combine)	"	1.15	1.21	1.25	2.63
Cutting corn	"	.80	.79	.86	.90
Picking corn	"	.44	1.11	-	1.02
Grinding feed	Lb.	1311	2312	1716	2267
Threshing grain	Bu.	-	98	-	168
Shelling corn	Bu.	40	82	113	124
Filling silo	Ton	-	3.12	8.89	8.76

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 10. The size of implement is, in general, proportional to the size of tractors. 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 three 16-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 the same sized 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 9 and table 10 cover only cases where but one kind of implement is used at a time.

Table 10
Acres Covered Per Hour with Implements of Different Sizes

Plowing

1-16" bottom	.44 acres		2-16" bottoms	.89 acres	
1-18" "	.50 "		3-14" "	1.16 "	
2-14" "	.78 "		3-16" "	1.33 "	

Disking

4'	1.18 acres	9'	2.65 acres	13'	3.83 acres
5'	1.47 "	10'	2.95 "	14'	4.13 "
6'	1.77 "	11'	3.24 "	15'	4.42 "
7'	2.06 "	11½'	3.39 "	16'	4.72 "
8'	2.36 "	12'	3.54 "	18'	5.31 "
				20'	5.90 "

Springtooth-Harrowing

6'	1.77 acres	8'	2.36 acres	9'	2.65 acres
7'	2.06 "	8½'	2.51 "	11'	3.24 "

Field Cultivating

6'	1.91 acres	7½'	2.39 acres	10'	3.18 acres
7'	2.23 "	8'	2.54 "	11½'	3.66 "

Spiketooth-Harrowing

12'	4.22 acres	18'	6.33 acres	22'	7.74 acres
14'	4.93 "	20'	7.04 "	23'	8.09 "
15'	5.28 "	20½'	7.22 "	25'	8.80 "
16'	5.63 "	21'	7.39 "	26'	9.15 "

Seeding Small Grain

7'	2.09 acres	9'	2.69 acres	12'	3.59 acres
8'	2.39 "	10'	2.99 "	14'	4.19 "

Planting Corn

2 row	1.83 acres	4 row	3.65 acres

Cultivating Corn

1 row	1.13 acres	2 row	2.26 acres

Mowing Hay

4½'	1.80 acres	5'	2.00 acres	7'	2.80 acres

Table 10
Acres Covered Per Hour with Implements of Different Sizes
(continued)

Harvesting Grain - Binder

6'	1.33 acres	8'	1.78 acres
7'	1.55 "	10'	2.22 "

Harvesting Corn - Binder

1 row	.84 acres

Picking Corn

1 row	.65 acres	2 row	1.38 acres