The Farm Tractor in Iowa

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Tractors have been sold in large numbers to Iowa farmers in the past two years. From the best information available it is estimated that there are something like 12,000 tractors in the state. This means that about one farm in 16 has a tractor.

A great many farmers who do not at present own tractors are considering seriously the question of whether or not a tractor is really a practical investment and if so, what size and type of tractor is best. In order to secure information which would aid in answering these questions, the agricultural engineering section of the Iowa Agricultural Experiment station made an investigation of the use of tractors on Iowa farms, and the results are presented in this circular.

The performance of a tractor when handled by an expert operator at a demonstration may be somewhat different from the performance at every-day work in the hands of the farm operator. It is the performance under actual working conditions that determines its practicality. Therefore, the investigation has been limited to observations of results secured with the tractor by farmers. The writer visited 61 farms to secure information at first hand. A considerable number of reports were also secured by mail, some of them representing careful accounts of the expenses and the work done with the tractor.

This circular gives a summary of 228 reports covering the 1918 operating season. Thirty-nine of these were secured by personal visits and 189 by mail. These were selected to meet the following requirements: First, that they must be reasonably near complete, and second,

Acknowledgement is made to Professors J. B. Davidson and C. K. Shedd for advice and assistance in the preparation of this bulletin.
that the tractor must have been used at least one full season. All 1918 reports on hand at the time of writing and which meet these requirements are included in this summary. A separate report is also included on 44 tractors discarded or sold in the last few years.

**DOES THE TRACTOR PAY?**

Out of 228 owners reporting there are 201 who consider the tractor a paying investment and 9 who do not. Eighteen owners were not sure whether it was paying or not. The owners of five machines which are not paying give the following reasons:

1. The operator lacks experience.
2. The owner has to keep as many horses as before.
3. A larger machine is needed. (This owner has a slow speed, two-plow tractor.)
4. Tractor packs the ground. It is too much bother.
5. Have lost all patience. Tractor is too much bother.

**RELIABILITY OF THE TRACTOR**

Of the three-plow tractor owners, 50 percent reported no time lost during the working season. The average time lost by all three-plow outfits was 3.6 days per year, which includes two tractors reported out of order for 60 days. Of the two-plow tractor owners, 59 percent reported no time lost. The average time lost by all two-plow outfits was 2.6 days per year, which includes one tractor reported as out of order for 21 days.

**THE DISPLACEMENT OF HORSES**

With our present machinery it is impractical, if not impossible, to operate the average corn belt farm entirely without horses. Even if a motor cultivator were used, horses would still be needed for some of the farm work, such as hauling bundles to the thresher and for corn husking. Under average conditions two horses will be needed for each 40 acres of corn under cultivation. The 1918 reports did not include the number of horses displaced, but there were 58 reports for the 1917 operating season which include a statement as to the displacement of horses. At that time the number of horses displaced varied from none to ten, the average being 3.3.

**SIZE OF TRACTOR**

Tractors are rated by their drawbar horsepower and belt horsepower and by the number of 14 inch plow bottoms they are designed to pull. It is customary to rate the drawbar horsepower as one-half the belt horsepower, as 9-18, 10-20, 15-30, etc. The belt horse power is determined by testing with a brake and can be determined quite accurately for any tractor. All manufacturers do not rate their tractors on the same basis. That is, a tractor which is rated at 20 horsepower on the belt may only deliver 18 or it may give as much as 24. The Society of Automotive Engineers recommends a standard of 25 percent surplus power above the rating.

Drawbar horsepower is that which is actually delivered to the tractor drawbar and which is useful in pulling implements or loads. It is less than the belt horsepower because considerable power is required to propel the tractor itself; some power is lost in friction of the gearing and some in slippage of the drive wheels. The drawbar horsepower which a tractor can deliver varies with the condition of soil and grade over which it travels, but under favorable conditions it should be somewhat more than one-half of the belt horsepower.

For average soil conditions a tractor which can deliver 10 or 12 drawbar horsepower will pull three 14 inch plow bottoms at a speed of from two to two and one-half miles per hour, or two 14-inch bottoms, at a speed of from two and two and one-half to three miles per hour. As a rule the footing for a tractor varies with draft of a plow. That is, where plowing is very hard the tractor footing is likely to be good, but where plowing is easy the ground is soft and the tractor wheels
will slip easily. On account of this it is usually more satisfactory to have two speeds on a tractor to take care of variation in plowing conditions rather than a plow with a variable number of bottoms.

FARMER OPINION AS TO SIZE OF TRACTOR

The 228 tractors included in this summary were distributed as follows: 44 were two-plow size, 153 were three plow size, and 31 were larger machines. Each tractor owner was asked to state what size of tractor would in his opinion be best adapted to his farm.

The two and three-plow tractors are considered best adapted to field work and the majority favor the three-plow. Some owners reported in favor of a four-plow tractor, but with one exception, this opinion was based on experience with a smaller tractor and not with a four-plow tractor. The following statements were made by owners of tractors pulling more than three plows:

"Have smaller tractor for field work."
"Would not pay for farm work."
"Too slow."
"Likes three-plow tractor he had before better for field work."
"Used in fall only."
"Three-plow better for field work."
"Has thresher. Plowing a side line."
"Does not pay for field work."
"Would rather have three-plow outfit for field work."
"Too large for field work."

Larger than three-plow outfits are at a disadvantage on account of weight. There is also a disadvantage in having four or more plows where there is trouble with the plow clogging. Four-plow tractors are now being built which weigh no more than many of the three-plow tractors which are in successful use. These may prove successful in field work. Owners are recommending more reserve power, more speed, lighter weight and gearing better enclosed rather than a tractor to pull more plows. The two-plow tractors which are recommended have working speeds of at least two and one-half miles per hour. Slower speed two-plow tractors have a small possible output of work per day for each man. The three-plow tractors have the advantage for belt work as they will handle fair sized threshers and ensilage cutters.

The two-plow outfit has the advantage when working on soft or plowed ground on account of its lighter weight. Twice as many owners of two-plow outfits use their tractors with a smoothing harrow alone as do owners of three-plow outfits. The lighter tractors get into a field earlier after a rain than is possible with the heavy tractors.

SIZE OF FARM

The three-plow tractors were found on farms having from 90 to 1,050 acres of cultivated land, the average being 249 acres. Two-plow tractors were used on farms having 80 to 550 acres of cultivated land, the average being 221 acres.

Table I shows how these two and three plow tractors are distributed on different sizes of farms. Ten owners did not report size of farm.

<table>
<thead>
<tr>
<th>Size of Farm (Acres in Crop)</th>
<th>[Under 100]</th>
<th>[100 to 150]</th>
<th>[150 to 200]</th>
<th>[200 to 250]</th>
<th>[250 to 300]</th>
<th>[300 to 400]</th>
<th>[400 to 450]</th>
<th>[Over 450]</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of two-plow tractors</td>
<td>2</td>
<td>9</td>
<td>8</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>42</td>
</tr>
<tr>
<td>Number of three-plow tractors</td>
<td>3</td>
<td>20</td>
<td>30</td>
<td>37</td>
<td>17</td>
<td>22</td>
<td>16</td>
<td>145</td>
<td></td>
</tr>
</tbody>
</table>

The tractors which are not considered by the owners to be paying investments are on the following sizes of farms: 130, 211 and 222 cultivated acres. Two of these owners did not give the size of farm. None of these owners indicated that the size of farm was the cause of the tractor not paying.
It may be noted that the tractors on the smaller farms usually do some custom work (that is, work for hire), either traction or belt. But even if the custom work is left out of consideration the investigation to date does not furnish definite information in regard to the smallest size of farm on which a tractor may be expected to prove a good investment.

A tractor can be used to best advantage on farms which require two or three men. The tractor can do the plowing, discing and harrowing. Two or three shifts of operators may be used if necessary. The horses may be used for seeding, planting, and other work not especially adapted to the tractor. In this way the horses and tractor may both be used to the best advantage. On very large farms, the tractor may be at a disadvantage, due to the fact that it is often difficult to secure competent tractor operators. A one-man farm cannot use the tractor to best advantage, because either the horses or tractor must stand idle. In some cases, two neighbors having small farms use a tractor together. This merely means that they are run as one farm with two men. A farmer having one or two boys in high school can use a tractor to very good advantage. The boys can look after the chores so he can put in a long day with the tractor during the spring work. Later when school is out, the boys will be able to help with corn cultivation and harvest.

TRACTOR USES

All of the tractors here reported are used for plowing. About three-fourths of them are used for discing and two-thirds on the binder. The tandem type of disc with a harrow behind is the favorite combination for preparing the seed bed, as it effectually erases all tractor tracks. Two-plow tractors pull 7 or 8-foot tandem discs with harrow. Three-plow tractors pull 9 or 10-foot tandem discs with harrow. Very few owners are using two binders on their tractors and most outfits require two men or a man and a boy to operate tractor and binder, altho in some cases, extension controls have been used with excellent success. Other tractor uses mentioned by owners are hauling, dragging roads, grading, haying, and pulling a corn picker, corn binder and corn cultivator.

As a source of belt power, the tractor is most often used with a feed mill. Other uses are: Thresher, wood saw, ensilage cutter, corn sheller and shredder. Twenty to 24 inch separators are commonly used with farm tractors of 20 to 25-belt horsepower. These give good results if not crowded and the grain is in good condition.

It is the opinion of the writer that the two and three-plow tractors will be used for belt work to a much larger extent in the future, and will replace to a great extent the larger steam and gas tractors now in use. To get the best results, small belt driven machines will have to be built especially for these smaller tractors so the available power may be used to the best advantage.

NUMBER OF DAYS USED PER YEAR

Ninety-eight of the reports on two and three-plow tractors included an estimate on the number of days used per year. The average for these 98 reports was 45 days and in most cases this was based on the more important farm operations and did not include any odd jobs. Twenty-two of the large tractors averaged 64 days use per year and were all used for custom work. These were used largely for threshing, silo filling, shelling and road grading. Field work was of minor importance.

QUALITY OF WORK

The quality of field work done with a tractor varies. If the operator is not careful, or the tractor and plow are not hitched properly, it is possible to do an extremely ragged job of plowing. This is most
often noticed where the plows start in at the ends. This is due either to not getting started in at the right place or to a plow which does not go into the ground quickly. It is also common to see places thru the field where the furrow wheel has jumped out of the furrow and thrown the plow partly out.

The following points are desirable to secure a good job of plowing:
1. A tractor which steers easily and quickly.
2. Headlands wide enough so that turn can be made easily.
3. A plow adapted to work with the tractor, properly adjusted and reasonably sharp.

If the tractor is not excessively heavy it will do an excellent job of discing and harrowing. This is due to having plenty of power and to the use of the tandem disc and harrow which finish the work in one operation.

One of the greatest advantages of the tractor is that it can do the work more quickly than the horses and therefore the work can be completed while the ground is in the best condition.

HOW LONG WILL THE TRACTOR LAST?

It is difficult to secure definite information on the length of service of a tractor. Naturally, the life of a tractor will depend on the design and construction, on how much it is used, and on what care is taken of it. An effort was made to secure information about tractors that have been worn out and 44 reports were secured on tractors that have been sold or traded in. The period of use varied from 11 months to 9 years, the average being 2 ½ years. Definite information as to the number of days used could not be secured.

The average sale or disposal price was 48 percent, slightly less than one-half, of the purchase price. This cannot be taken as a true guide to the depreciation of the tractor, as several of these machines were unsatisfactory in size and would be traded in to a considerable disadvantage. Eleven owners indicated that their machines did not pay. Sixteen owners reported their machines as being too small or slow. Five men of the 44 indicated that they were thru with tractors, all the others having reinvested or quit farming. The following are some of the statements of owners of non-paying tractors:

tractors:

"Tractor worn out when bought."
"Too wet in spring."
"Farm not tiled."
"Wouldn't run half the time."

In one instance a farmer discarded two tractors as being worthless but he was very enthusiastic about his third machine. In another case a man had used two kerosene burning tractors for a short period each. His third was a gasoline tractor. He states that the gasoline tractor is much more satisfactory where he has to depend on hired help for operators.

Tractor design and construction have been greatly improved in the past five years, so that the report on the length of service of an old type of tractor is not necessarily final evidence of the service that may be expected from those now on the market.

While definite figures are not available, it is the judgment of the writer that 3,000 hours is a conservative estimate of the service which may be expected of a tractor of standard construction, provided the tractor is not overloaded, is given good care and is properly housed when not in use. These are conditions which should be provided for by any tractor owner. This would be 25 days work per year for 12 years, or 50 days work per year for 6 years, or 100 days work per year for three years. Some tractors in the hands of good operators will no doubt give much longer service than this and on the other hand, some tractors will wear out more quickly than this in the hands of the average tractor operator.
A tractor purchased from a reliable manufacturer and of proven design is not likely to depreciate as rapidly as some of the so-called "freak designs". Long life in a tractor requires sturdy construction, an efficient lubricating system, an effective air cleaner, and enclosed working parts as far as possible.

LUBRICATION IS VERY IMPORTANT

The lubrication of a tractor is very important. The tractor must not only have plenty of oil but it must be of suitable quality and consistency. This is much more important in the case of the tractor than with the automobile, as it has to work very much harder. In the selection of a lubricating oil, the tractor owner had best take the advice of his tractor manufacturer.

All nuts and rivets should be kept tight and the tractor should be housed when not in use.

TRACTOR FUELS

In Iowa kerosene is used to a greater extent than gasoline as a tractor fuel. Out of 191 two and three-plow tractors, 34 reported that gasoline was used as a fuel and 8 reported that a mixture of gasoline and kerosene was used. All others used kerosene. The development of the kerosene tractor has not reached the stage where it can be said that a kerosene burning engine gives no more trouble than a gasoline engine, but it can be said that the average tractor operator can burn kerosene successfully if the tractor is adapted to that fuel. Fuel economy tests with tractors show that a kerosene burning motor can get almost as much work out of a pound of kerosene as a gasoline tractor can get out of a pound of gasoline. As kerosene is heavier than gasoline, some kerosene tractors are getting more work per gallon of fuel than gasoline tractors.

There is only one advantage worth mentioning in favor of using kerosene as a tractor fuel. This is its cost. The price of kerosene is approximately one-half the price of gasoline, so that with the average two or three-plow tractors kerosene represents a saving from 20 to 25 cents per hour in the cost of fuel. It may also be said that kerosene is less dangerous than gasoline, but we have become so used to handling gasoline in connection with the automobile that this point has little if any weight with the average operator.

The disadvantages connected with burning kerosene in a tractor are several but are being overcome to a large extent by improvements in design. Gasoline must be used for starting. Unless thoroly vaporized, kerosene has a tendency to condense on the spark plugs and interior of the combustion chamber. This is especially true if the motor is not hot and it may cause the spark plugs to misfire. Also, any condensation collecting within the cylinder is apt to find its way past the pistons and be mixed with the crank case oil. When a circulating system of lubrication is used the crank case oil must be renewed more frequently than would be necessary with the same engine burning gasoline. Generally more power can be secured from the same engine when using gasoline than when using kerosene. In some kerosene burning engines there is no provision for turning off the heat from fuel mixture and a few such tractors will give more power on kerosene than gasoline.

Where water is injected into the fuel mixture, considerable attention may be necessary to regulate the amount of water used.

COST OF OPERATION

The principal items to be considered in the cost of tractor operation are labor, fuel, oil, repairs, depreciation, Interest and housing.
Fuel: The average fuel consumption of the 153 three-plow tractors included in this investigation was 22 gallons per 10 hours. For the 42 two-plow tractors the average was 16.3 gallons. In Table IV this is figured at 12¢ per gallon.

Lubricating Oil: There is a great variation in the amount of lubricating oil used for different tractors. In the reports received the oil consumption of three-plow tractors varied from one-half to three gallons per day, the average being 1.5 gallons per 10 hour day. The two-plow tractors used one-fourth to two gallons of oil per day with an average consumption of 1.1 gallon per 10 hour day. An oil price of 75¢ per gallon is assumed in Table IV.

Repairs: The repair expense on a farm tractor is a very indefinite amount and of course depends on the materials and workmanship of the tractor and the care which is given it. Of the three-plow tractors 36 percent reported that no repairs had been needed. The largest repair bill was $200. The average was $22 per year. For two-plow tractors 37.5 percent had no repairs. The largest bill reported was $150, the average being $16.50 per year. These tractors had been in use a little over two seasons on the average. It is to be expected that the repair cost would be greater for the succeeding years. In Table IV the repair cost is based on a yearly charge for repairs just double the averages given above.

Depreciation: A tractor built by a reliable manufacturer and of suitable size for average conditions should have a depreciation nearly in proportion to the amount of time it is used, provided it is well housed when not in use. That is, depreciation should be figured on the basis of the number of hours or days used rather than on the age of the machine in years. If the machine will last 6 years when used 50 days per year, this would give a working life of 3,000 hours. Dividing the cost of the tractor by this, we have the depreciation charge per hour. Table II shows the depreciation charge per hour for tractors ranging in price from $500 to $2,000 and a working life ranging from 1,000 to 6,000 hours.

<table>
<thead>
<tr>
<th>Working life of tractor</th>
<th>First cost of tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>1000 hours</td>
<td>.60</td>
</tr>
<tr>
<td>2000 hours</td>
<td>.25</td>
</tr>
<tr>
<td>3000 hours</td>
<td>.17</td>
</tr>
<tr>
<td>4000 hours</td>
<td>.13</td>
</tr>
<tr>
<td>5000 hours</td>
<td>.10</td>
</tr>
<tr>
<td>6000 hours</td>
<td>.08</td>
</tr>
</tbody>
</table>

If we could tell the working life of tractors we could figure the depreciation cost exactly. Our most successful tractors used for field work have not been in use long enough to determine their life.

Interest: The average interest to be charged against the use of tractor for one year may be found by multiplying the usual rate of interest by one-half the purchase price of tractor, this being the average value of the tractor during its life. The fact that the interest charge on a tractor is greater when new is offset by the repair expense being much less on the new machine.

Table III gives the average interest charge per hour for different prices and different amounts of use per year.
TABLE III—INTEREST CHARGE PER HOUR'S USE OF TRACTOR AT 6%

<table>
<thead>
<tr>
<th>Hours used per year</th>
<th>First cost of tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$500</td>
<td>$750</td>
</tr>
<tr>
<td>Interest charged per hour</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>.075</td>
</tr>
<tr>
<td>300</td>
<td>.05</td>
</tr>
<tr>
<td>400</td>
<td>.04</td>
</tr>
<tr>
<td>500</td>
<td>.03</td>
</tr>
<tr>
<td>1000</td>
<td>.015</td>
</tr>
</tbody>
</table>

In order to estimate the cost of tractor operation it is necessary to assume a working life for the tractor so that we may figure its depreciation. The following table is based on a working life of 3,000 hours, 400 hours use per year and a first cost of $1,000 for a two-plow tractor, and $1,250 for a three-plow tractor. A labor cost of 50¢ per hour is assumed. Housing is figured on the interest and depreciation of a $100 building.

A study of table IV indicates very clearly that the big items in the cost of operation are labor, fuel and depreciation. The latter is too often neglected when figuring costs. In order to reduce the fuel cost it is desirable to burn kerosene and to avoid using rich mixtures. The depreciation cost may be reduced by the careful selection of a tractor and by the proper care of the machine.

TABLE IV—COST OF OPERATION PER HOUR AND PER ACRE

<table>
<thead>
<tr>
<th></th>
<th>2-Plow Tractor Cost, $1000</th>
<th>3-Plow Tractor Cost, $1250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>.50</td>
<td>.59</td>
</tr>
<tr>
<td>Fuel—Kerosene at 12c</td>
<td>.164</td>
<td>.264</td>
</tr>
<tr>
<td>Oil at 75¢ per gallon</td>
<td>.062</td>
<td>.112</td>
</tr>
<tr>
<td>Repairs</td>
<td>.073</td>
<td>.098</td>
</tr>
<tr>
<td>Depreciation, 3000 hours, working life</td>
<td>.33</td>
<td>.42</td>
</tr>
<tr>
<td>Interest, 400 hours per year</td>
<td>.075</td>
<td>.069</td>
</tr>
<tr>
<td>Housing</td>
<td>.03</td>
<td>.03</td>
</tr>
<tr>
<td>Total</td>
<td>$1.286</td>
<td>$1.514</td>
</tr>
<tr>
<td>Average number acres plowed, 10 hours</td>
<td>7.3</td>
<td>8.8</td>
</tr>
<tr>
<td>Cost per acre</td>
<td>$1.76</td>
<td>$1.72</td>
</tr>
</tbody>
</table>

SUMMARY

1. Between 85 per cent and 90 per cent of the tractors investigated are considered by their owners to be paying investments.

2. The principal reason for failure of those that do not pay are: Lack of experience or patience on the part of the operator, or the use of a tractor which is unreliable in construction, or unsuited to the conditions.

3. The tractors best adapted to field work in Iowa are the two and three-plow outfits. Two-plow outfits should have a working speed of at least two and one-half miles per hour. The average two-plow outfit has the advantage on soft ground due to its lighter weight.

4. For belt work, especially small threshers and ensilage cutters, the average three-plow outfit has an advantage.

5. A kerosene burning tractor is desirable from the standpoint of economy, but requires more skill on the part of the operator.

6. Depreciation is usually the largest single item in the cost of operation and is controlled largely by careful selection and operation of the tractor.