5-1956

Farm Labor, Power, and Machinery Performance

J. Ulivilend
South Dakota State University

C. H. Benrum
South Dakota State University

FILE COPY

CIRCULAR 131 MAY 1956

farm labor, power, and machinery performance

IN EAST CENTRAL SOUTH DAKOTA

AGRICULTURAL ECONOMICS DEPARTMENT
AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE, BROOKINGS

Contents

Summary

There has been a need for information on rates of performance of farm labor, power, and machinery for crop operations in east central South Dakota. Such information is of vital importance in computing cost for farm planning and budgeting.

While there had been some studies on rates of performance in other states, the results were not applicable to South Dakota. Different methods had been used in making these surveys, with the interview method based on farm records and farmers' estimates being the most frequent. A study made in 1950 in the proposed Oahe irrigation area was considered inadequate for determining rates of performance because of many inconsistencies.

The data presented here were based on a survey made in 1951. In making the survey, farmers were contacted and different field operations were timed for a period of 1 hour. Two hundred five schedules were taken in the proposed Oahe irrigation area of 1950. The data were tabulated and an equation developed by Burdick was used in calculating the rates of performance for different machines on different farming operations. These rates of performance were used in figuring labor, power, and fuel requirements for small grain and row crops on a per acre basis, with estimates made for irrigated as well as dryland conditions.

When the size of tractor and machine was held constant, it was found that speed and size of field were the two most influential factors in determining rates of performance. As the length of the field decreased, rates of performance decreased. The rate of travel was the most important factor in influencing rates of performance.

In comparing requirements for raising comparable crops on dryland and irrigated land, it was found that it takes about three times as many man-hours to produce the crop under irrigation as it does to produce it on dryland.

South Dakota agriculture is changing rapidly and as a result there will be some need for adjustments in the data as here presented. But since the data are presented in physical terms, they can be used with any level of prices in computing costs.

Farm Labor, Power, and Machinery Performance
IN EAST CENTRAL SOUTH DAKOTA

JAMES ULVILDEN and CHARLES H. BENRUD[1]

Introduction

The problems of the farm manager are continuous. In attempting to maximize his income, he must constantly examine alternative methods of production and combinations of resources. As guides in making decisions as to these alternatives, he needs a vast amount of physical data on the costs as well as the returns of alternative plans. These data must be as realistic as possible if his farm plans are to be of maximum value.

Knowledge of the costs involved in producing the various crops is basic to farm planning. To determine these costs, information on the labor, power, and machinery requirements of each crop is essential. These requirements are made up of the totals for the individual operations necessary, such as plowing, harrowing, seeding, and harvesting, which in turn are dependent upon such factors as the size of machinery, size of field, and condition of soil. In a given area, a change from dryland to irrigation farming will usually bring about appreciable changes in one or more factors.

In order to obtain data as to the labor, power, and machinery requirements for crop production in east central South Dakota, a study was made in 1951 as part of a cooperative project of the South Dakota Agricultural Experiment Station and the Bureau of Reclamation, U. S. Department of Interior.

As a result of this study, information has been compiled concerning time and fuel requirements for

[1]Former Graduate Research Assistant and Assistant Economist, South Dakota State College Agricultural Experiment Station.

most of the crops and cropping operations of east central South Dakota, using various sizes of equipment. This information can be used to make comparisons between alternative crops, methods of production, tractor and machinery sizes, and lengths of fields, as well as between owning a machine and hiring custom work. Since it is given in physical terms, it can be used with any set of prices to obtain monetary costs and relationships. While the data are based on dryland conditions, estimates have also been made for irrigation.

Historical Background

Previous to the 1951 study, little information was available on labor, power, and machinery rates of performance for different farming operations in east central South Dakota. A study made by Hampson and Christopherson in 1930 compared the performance of tractor and horse power in Potter County, using daily records kept by farmers.[2] Most of its data have now been out of date for some time, however, due to changes in both power and machinery.

In 1948, Miller, Quentin, and George presented a study of the cost of operating machinery on Nebraska farms, based on farmers' estimates of the time spent in various operations.[3] Obviously, however, their accuracy could be no better than the estimates made by the farmers, who had kept no records.

Burdick, in 1949, introduced a new technique of field crop labor analysis[4].

In a study of labor and machinery requirements for various crops in Colorado, he shifted from analysis of historical crop data to a more theoretical general purpose analysis. This could be used more easily under changing conditions for forecasting the effects of these changes. His approach was to attempt to analyze farm operations before they were performed, instead of securing a record of actual hours for every operation after the work was done. The factors which received attention in the development of the analysis were as follows:

1. Length of field
2. Width of machine
3. Speed of travel
4. Time required for turns
5. Soil and weather conditions
6. Possibility of combining operations
7. Service time required
8. Unexpected breakage and delays.

[2] C. M. Hampson and Paul Christopherson, *Tractor and Horse Power in the Wheat Area of South Dakota*, South Dakota State College Agricultural Experiment Station Circular 6, BAE, USDA Cooperating, 1932.

[3] Frank Miller, et. al., *Cost of Operating Machinery on Nebraska Farms*, Nebraska Agricultural Experiment Station Bulletin 391, 1948.

[4] R. T. Burdick, *A New Technique for Field Crop Labor Analysis*, Colorado Agricultural Experiment Station, Tech. Bul. 36, June 1949.

After a study of these factors was made, it was found that many of them could be measured. The equation used, together with Burdick's explanation, is as follows:

$$T = \frac{8.25}{SW}\left(1 + \frac{16\ SN}{3L}\right)(1+A)$$

In this equation, T is the hours per acre per operation for once over; S is the speed of travel in miles per hour; W is the effective width of the machine in feet; L, is the length of the field in rods; N is the time required for turning at ends of a field expressed in fractions of a minute; and A is the over-all service and rest allowance expressed as a decimal.

In the equation, the first term, $\frac{8.25}{SW}$, gives the hours required to cover one acre when no allowance is made for turns or any delay. The process for development of this term was as follows: an acre of ground covers 43,560 square feet; a machine, 1 foot wide, would go 8.25 miles to cover 1 acre. With a speed of 1 mile per hour, it would also take 8.25 hours to cover the acre. This may be considered as the base or starting point. It is apparent that a machine 2 feet wide, other things being equal, would cover the acre in half the time or 4.125 hours. It is also apparent that a speed of 2 miles per hour would cut the time in half. The hours for one-foot machines at 1 mile per hour, if divided by the product of speed and width, will give the hours for any combination of speed and width. Hence, the first term of the equation gives the straight time to which must be added the necessary time for turns and other items which delay the work.

The second term, $\frac{16\ SN}{3L}$, gives the added time involved in turning around at the end of the field. This was secured as follows: a field 80 rods long was used as a base for this calculation. The one-foot machine is going 8.25 miles in an 80 rod field and will turn 33 times in covering an acre, which will require 33 minutes or 0.55 hour when turns require 1 minute each. This is 6 and ⅔ per cent of the 8.25 hours required for straight work at a one-mile speed. But 6 and ⅔ per cent is the same as 1/15. It is apparent that a field 40 rods long would require twice the time for turns, compared to the 80 rod field. If a turn is made in ½ minute, this would be one-half the time for one minute turns. Speed works in an opposite manner. With a 2 mile speed and no change in the time per turn, the time per acre for turns will be twice as large a percentage with the 1 mile speed. Bringing all of the items together this term reads:

$$\frac{80\ SN}{15L} \text{ which reduces to } \frac{16\ SN}{3L}$$

It is necessary to add the whole number 1 in the parenthesis so that the straight time can be multiplied by a rate which will include itself, plus the added time for turns.

The third term in the equation introduces the service allowance which is an over-all factor of safety, added to the combined time for straight work, plus time for turns. A covers all other items not otherwise identified. Again, the whole number is added to permit direct multiplication in the equation.

The factors mentioned here will vary, depending upon the type of equipment used, and the operator will also cause variations. But these variations, if measured, can be used in making the calculations. The development of this equation was a marked step forward in the study of labor and machinery performance, since it can be continuously adapted to technological changes in agriculture.

Burdick's results, however, as distinct from his method, could not be applied to east central South Dakota, since farming conditions vary considerably even between areas within a state, and therefore almost certainly between states. Differences in climate, soil, topography, and community customs will cause variations in the types of crops grown and the operations and machines used. Whenever possible, data to be used in helping farm managers to make decisions should be based on conditions as similar as possible to those existing in the area in which they live.

For these reasons, a random sample survey was taken in east central South Dakota in 1950 to obtain information on typical machines, sequence and number of operations, and rates of performance. This information was obtained by interviewing individual farmers, whose estimates provided the answers to the questions used in the survey.

In this survey, the data gathered on typical machines and on sequence and number of operations were assumed to be accurate; but the information on rates of performance was not satisfactory.

For example, the estimates of the average acres plowed per hour with a 3-14-inch plow and a 21 to 29 horsepower tractor were lower than those for a 2-16-inch plow and a 14-20 horsepower tractor. Likewise, for the harrowing operations the acreage per hour for a 20-foot harrow was less than one-half that of a 30-foot when the same size tractor was used on both implements.

This was opposite to what should logically occur, since the larger implement would normally decrease the speed of the tractor. As a result of these and other inconsistencies, the information on rates of performance obtained in the 1950 survey was not considered accurate enough for use in farm planning.

Methods Used in the 1951 Study

While neither Burdick's results nor those of the 1950 survey provided the final answers as to labor and machinery performance in east central South Dakota, each had, nevertheless, made a definite contribution. What remained was the need for accurate information on speeds used and time lost, in order to be able to calculate the rates of performance in question.

To obtain this information, a survey was made in the summer of 1951. Farmers were contacted in the area and different field operations were timed for a 1-hour period.

The farmers included in the survey were selected at random as they were found carrying on the various operations. If, for example, the enumerator was seeking information on cultivating, he would drive along the road and whenever he came to someone cultivating corn he would stop and time the operation. This procedure was more satisfactory than selecting the farm in advance, because there was no way to know just when the operations would be carried on.

Two hundred five schedules were taken in this area of east central

South Dakota in 1951. With the aid of a stop watch, information was obtained on (1) rate of speed, (2) time lost per hour because of breakdowns and other stops, (3) time lost turning on ends, and (4) time for servicing before daily work was started.

After the operations had been timed, the farmer was interviewed to obtain information on the size of the implement, the size of the tractor, and the operating gear of the tractor. This information was obtained for the following operations: plowing, harrowing, cultivating, mowing, swathing, and combining. Data obtained on these operations then were used in working out the information for most of the various field operations by means of Burdick's equation.

Information on performance under proposed irrigated conditions was also calculated by using Burdick's method. The data for the equation were based, in part, on the 1951 survey, and also on previous studies on irrigation in other states.

Sizes and types of machines used and the number of times over for different operations were based on studies of irrigation practices made in central Nebraska and the lower Yellowstone in 1950 by the Bureau of Agricultural Economics (BAE) in cooperation with South Dakota and North Dakota Agricultural Experiment Stations. Standards set up by the Bureau of Reclamation for irrigation in the area were also used in some cases.

No data on putting up hay were secured in the 1951 survey. Most of the data used in developing the requirements for haying were based on previous studies made in other states.

Performance for Selected Dryland Operations

In presenting the estimates made regarding labor, power, and machinery for selected dryland operations, it is convenient to divide the data into three parts: (1) the factors affecting rates of performance; (2) the calculations that were made in determining rates of performance; and (3) a presentation of the total requirements per acre for small gains, corn, and hay.

FACTORS AFFECTING RATES OF PERFORMANCE

There are many factors influencing rates of performance. Some of these factors are: size of field, size of machine and power, time lost turning on ends, time lost because of breakdowns and other delays, and speed used. When the size of the machine and the tractor were held constant, it was found that speed and size of field were the two most influential factors. As the length of the field decreased, the rates of performance decreased rapidly. The rate of travel was probably the most important factor in influencing rates of performance.

Rate of Travel. In the 1951 study, it was found that speeds ranged from 3 miles per hour to 4.5 miles per hour, depending on the type of tractor being used and the field operation being performed. Information on the Nebraska Tractor Tests shows speeds for the rated load for different makes of tractors varying from 3 to 5 miles per hour.[5] However, for the tractor most common in the area studied, the speed for the rated load is approximately 4 miles per hour.

The survey on speed indicates that when the tractor is operating at the rated load, the rate of travel on the actual field operation is similar to the speed found in the Nebraska tractor test.

There is a slight increase in speed for some field operations which require considerably less power than the power required for the rated load. On the other hand, the speed decreases for some operations which have other limitations on speed besides power; for example, the first cultivation of corn.

The speeds that were obtained for the different field operations in the 1951 survey are shown in table 1.

Time Lost per Hour. It was found that for most field operations the time lost per hour was about 5 minutes. There were, however, operations in which more time was lost per hour. They were operations such as drilling and combining grain and planting and picking corn. These operations required more time because it was necessary to make more stops for such things as putting seed in the drill and corn in the planter. Speed was a limiting factor in all of these operations.

Sizes and Types of Machines. Before rates of performance can be calculated, it is necessary to know something about the sizes and types of machines and power used in the area. The sizes of the most common tractors and implements on farms in east central South Dakota were used. This information was obtained from the random sample survey taken in 1950.

Sizes of the most common tractors and implements on farms in east central South Dakota are shown in table 2.

A range in size was reported for most implements, but, as shown in the table, there is a tendency for one or two sizes to predominate. For example, nearly one-half of the plows in the area were 3-14-inch; one-fourth were 2-14-inch; and all other sizes combined accounted for only one-fourth.

Data were also gathered regard-

Table 1. Rates of Travel and Time Lost for Dryland Operations Timed in East Central South Dakota, 1951

Operation	Total Cases	Av. Speed (MPH)	Av. Time Lost Per Hr. (Min.)*
Plowing	33	4.0	4.8
Harrowing	6	4.5	4.7
Cultivating			
1st time	42	3.5	5.5
2nd time	51	4.0	5.3
3rd time	10	4.5	5.0
Swathing Grain	21	4.5	4.5
Combining (self prop.)	38	3.5	10.2
Mowing	4	4.5	4.6

*For the calculations made in tables, all figures on average time lost per hour were rounded off at 5.0 minutes, except for combining, and the average time lost here per hour was rounded off at 10.0 minutes.

[5] *The Nebraska Tractor Tests and Supplement*, Nebraska Agricultural Experiment Station Bulletin 397, January 1950.

Table 2. Percentage Distribution of Tractors and Implements on Sample Farms East Central South Dakota (1950)*

Kind and Size of Tractor or Implement	Farms Reporting	Kind and Size of Tractor or Implement	Farms Reporting
	Percent		Percent
Tractor DBHP		Corn Planter	
Less than 16	14	2-Row	68
16-22	65	4-Row	28
Over 22	21	Others	4
Plow		Corn Cultivator	
2-14″	24	2-Row	92
2-16″	16	Others	8
3-14″	49	Corn Pickers	
Others	11	1-Row	73
Disk (single)		2-Row	27
10′	42	Mower	
15′	32	5′	11
Others	26	6′	26
Harrow		7′	63
20′	27	Swather	
25′	40	12′	60
30′	21	15′	14
Others	12	Others	26
Drill		Combine	
10′	27	5′	29
11′	35	6′	41
12′	18	12′	20
14′	16	Others	10
Others	4		

*Where implements of a particular size did not constitute at least 10 percent of all sizes, these implements were included in the "others" category.

ing the size tractor used on tillage implements of various sizes. This information is presented in table 3.

The information indicates the power and machinery preference in the east central South Dakota area. Conditions of soil and topography influence the power requirements a great deal. In this area tractors ranging from 16 to 22 drawbar horsepower (DBHP), which are commonly referred to as 2-plow tractors in the Corn Belt, are used more frequently on 3-bottom plows than are

Table 3. Percentage Distribution of Size of Tractor Used on Tillage Implements of Various Sizes on Sample Farms

Type and Size of Implements	Total Cases	Size of Tractor Used: Less Than 16 DBHP	16-22 DBHP	Over 22 DBHP
		%	%	%
Plow				
2-14″	18	6	83	11
2-16″	13	23	77	—
3-14″	56	2	60	38
Disk				
10′	18		88	12
15′	21	[illegible]	57	38
Harrow				
20′	17	6	82	12
25′	54	6	63	31
30′	27	4	37	59

the larger tractors. It was also shown that the smaller tractors were used on the large disks and harrows which usually require larger tractors.

The most common tractor size in this area falls in the 16 to 22 drawbar horsepower range. This particular size tractor is the most common on all sizes of farms, as shown in table 4. From the evidence presented, it appears that when acreage increases, the size of tractor does not necessarily increase, but another tractor of the same size is added.

Effective Width. There are a number of operations where the entire width of the machine is not used at all times. This may vary, depending on the operator, but it is a factor that must be considered when figuring rates of performance. For such operations as disking, harrowing, drilling, swathing, raking, and mowing there will be some overlap. This will not be true for row crops where, because of the nature of the operation, the full width of a machine will be used and no overlap will be possible.

In making the calculations on rates of performance, the effective widths of these machines where overlap exists were considered to be 95 percent of the actual width of the machine.

Length of Field. Information was not obtained on the typical lengths of fields in this area. It is known that as the length of field decreases, the rates of performance become less because of the time lost turning on ends. The time required to cover an acre of land increases as the fields become smaller, assuming all other conditions affecting rates of performance are the same.

In this study, for purposes of calculating rates of performance for dryland conditions, all fields were assumed to be 80 rods long.

The differences in rates of performance resulting from fields of different lengths appear in table 5.

Fuel Consumption Rates. The estimated fuel consumption was based on the Nebraska tractor tests

Table 4. Percentage Distribution of Number and Size of Tractors per Farm by Number of Acres in Cropland

Number and Size of Tractors per Farm	Acres of Cropland: Less Than 250 A.	250 to 500 A.	Over 500 A.
	%	%	%
Percentage of farms with one tractor	92	60	6
Percentage of farms with two tractors	8	40	94
Percentage of farms with:			
One tractor of less than 16 DBHP	8	7	----
One tractor with 16-22 DBHP	80	40	6
One tractor with more than 22 DBHP	4	13	----
Two tractors, both less than 22 DBHP	8	31	56
Two tractors, one less than 22 and one over 22 DBHP	----	6	25
Two tractors, both over 22 DBHP	----	3	13

Table 5. Comparison of Rates of Performance for Different Length Fields

Implement: Kind	Size	Length Field (Rods)	Speed (MPH)	Min. Lost Per Hr.	Hrs. Per A.*
Plow	3-14″	160	4.0	5	.67
Plow	3-14″	80	4.0	5	.70
Plow	3-14″	40	4.0	5	.76
Plow	3-14″	20	4.0	5	.87

*20 seconds allowed for turning on ends. These are calculated rates using Burdick's equation and data from the 1951 survey.

of 1950. It was assumed that the tractors were not quite as efficient on the farm as they were when the experts were handling them in the Nebraska tests. To allow for faulty adjustment and normal wear, 10 percent was added to the Nebraska tractor test requirements in calculating these fuel consumption rates.

Fuel consumption of the tractors varied with drawbar horsepower ratings. Therefore, the average fuel consumption for tractors in the 16 to 22 DBHP range was used.

Fuel consumption for engines on combines and balers was, in most cases, comparable to that for tractor engines; therefore, the Nebraska tractor tests fuel consumption rates were also used for these engines.

Another factor that entered into the calculation of fuel consumption was the load each operation placed on the tractor. The fuel consumption in the Nebraska tractor test was based on full load. Some operations, such as plowing and disking, may place a full load upon the tractor used. Others, such as mowing, may place only 10 percent of full load on the tractor.

As fuel requirements are based on the load placed on the tractor, it was necessary to find some basis for determining the percentage of full load placed upon the tractor by different field operations. H. P. Bateman, in a study in Illinois, found a relationship between fuel consumption and load placed on the tractor. His findings are shown in table 6.

The information in this table was used in estimating the fuel consumption presented in tables 7 and 8. The percentage changes were applied to the full load requirements given in the Nebraska tractor tests to determine the fuel requirements for different operations.

CALCULATIONS OF RATES OF PERFORMANCE

Using this information on factors influencing rates of performance, the next step was to calculate the rates of performance. In calculating the rates of performance, there were two size groupings of tractors used. The most popular size, as shown in table 4, was 16 to 22 DBHP. This grouping was used in the calculations shown in table 7.

Another grouping, 23 to 27 DBHP, was also used to take care of the tractors not included in the first grouping. These calculations are shown in table 8.

REQUIREMENTS PER ACRE FOR SMALL GRAIN, CORN, AND HAY

For purposes of budgeting it was felt that it would be more convenient if the total labor and fuel requirements per acre were presented

Table 6. Relationship Between Fuel Consumption and Load Placed on Tractor

Operation	% of Full Load	Gals. Fuel Per Hr.	Fuel as % of Full Load
Tandem Disk-Plowing	100	2.85	100
Plowing	80	2.50	87
Harrow	50	2.16	75
Drill	40	1.92	67
Cultivator 2-row	30	1.85	64
Cultivator 2nd & 3rd	20	1.72	60
Mowing	10	1.34	47
Corn Picking	40	1.96	68

Source: H. P. Bateman, "Effect of Full Load on Farm Machine Operating Economics," *Agricultural Engineering*, 24:111-114, April 1943.

for small grains, corn, and hay.

In setting up the labor and fuel requirements on a per acre basis, it was necessary to know the number of times each operation was performed for individual crops. This information was taken from the 1950 survey.

Small Grain. The operations for all small grains were somewhat similar; therefore, no breakdowns were made for such crops as oats, barley, and wheat. The calculations made represent requirements for small grain crops under different conditions.

According to data gathered, there seemed to be a sizable amount of both spring and fall plowing in central South Dakota. Thus, calcula-

Table 7. Estimated Rate of Performance and Fuel Consumption for Dryland Field Operations With Tractors Ranging From 16-22 in Drawbar Horsepower, East Central South Dakota

Implement Kind	Implement Size	Speed (MPH)	Min. Lost Per Hr.	Tractor Hrs. Per A.*	Gals. Fuel Per Hr.†	Gals. Fuel Per A.
Plow	2-14"	4.0	5	1.10	1.9	2.09
Plow	2-16"	4.0	5	1.00	2.0	2.00
Plow	3-14"	4.0	5	.70	2.1	1.50
Disk (single)	10'	4.0	5	.24	1.7	.41
Disk (single)	12'	4.0	5	.21	1.7	.36
Disk (single)	15'	4.0	5	.17	1.8	.31
Harrow	20'	4.5	5	.10	1.7	.17
Harrow	25'	4.5	5	.08	1.7	.14
Harrow	30'	4.5	5	.07	1.8	.13
Drill	10'	4.0	10	.27	1.5	.40
Drill	11'	4.0	10	.24	1.5	.36
Drill	12'	4.0	10	.23	1.5	.34
Corn Planter	2-row	4.0	15	.43	1.5	.65
Corn Planter	4-row	4.0	15	.21	1.5	.31
Cultivator	2-row					
1st time		3.5	5	.38	1.5	.58
2nd time		4.0	5	.34	1.5	.52
3rd time		4.5	5	.31	1.5	.47
Corn Picker	1-row	3.0	15	1.2	1.5	1.80
Corn Picker	2-row	3.0	15	.55	1.5	.83
Combine	6' (12' swath)	2.5	10	.39	3.0	1.20
Swather	10'	4.5	5	.24	1.4	.34
Swather	12'	4.5	5	.20	1.4	.28
Swather	15'	4.5	5	.16	1.4	.22
Mower	6'	4.5	5	.41	1.0	.41
Mower	7'	4.5	5	.35	1.0	.35
Side Delivery Rake	7' swath	4.5	5	.35	1.0	.35
Side Delivery Rake	8' swath	4.5	5	.30	1.0	.30

*20 seconds allowed for turning on ends. Length of field—80 rods.
†Fuel requirements based on Nebraska tractor tests plus 10 percent for faulty adjustments and normal wear.

Table 8. Estimated Rate of Performance and Fuel Consumption for Dryland Field Operations With Tractors Ranging From 23-27 in Drawbar Horsepower, East Central South Dakota

Implement		Speed	Min. Lost	Tractor Hrs. Per	Gals. Fuel	Gals. Fuel
Kind	Size	(MPH)	Per Hr.	A.*	Per Hr.†	Per A.
Plow	3-14″	4.0	5	.70	2.5	1.75
Disk (single)	10′	4.0	5	.24	2.2	.53
Disk (single)	12′	4.0	5	.21	2.2	.46
Disk (single)	15′	4.0	5	.17	2.3	.39
Harrow	20′	4.5	5	.10	2.0	.20
Harrow	25′	4.5	5	.08	2.0	.17
Harrow	30′	4.5	5	.07	2.0	.14
Drill	10′	4.0	10	.27	1.8	.49
Drill	11′	4.0	10	.24	1.8	.43
Drill	12′	4.0	10	.23	1.8	.41
Corn Planter	2-row	4.0	15	.43	1.8	.78
Corn Planter	4-row	4.0	15	.21	1.8	.38
Cultivator	2-row					
1st time		3.5	5	.38	1.8	.69
2nd time		4.0	5	.34	1.8	.62
3rd time		4.5	5	.31	1.8	.56
Corn Picker	1-row	3.0	15	1.2	1.8	2.0
Corn Picker	2-row	3.0	15	.55	1.8	1.0
Combine	12′ self prop.	3.5	10	.22	3.7	.82
Swather	10′	4.5	5	.24	1.6	.38
Swather	12′	4.5	5	.20	1.6	.32
Swather	15′	4.5	5	.16	1.6	.26
Mower	6′	4.5	5	.41	1.3	.53
Mower	7′	4.5	5	.35	1.3	.46
Side Delivery Rake	7′ swath	4.5	5	.35	1.3	.46
Side Delivery Rake	8′ swath	4.5	5	.30	1.3	.40

*20 seconds allowed for turning on ends. Length of field—80 rods.
†Fuel requirements based on Nebraska tractor tests plus 10 percent for faulty adjustments and normal wear.

Table 9. Labor and Fuel Requirements for Small Grain Following Corn in East Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implements		Times	Total Tractor Hrs.	Total Gals. Fuel	Total Man-Hrs.
Kind	Size	Over	Per A.	Per A.	Per A.
Disk (single)	12′	2	.42	.72	.44
Harrow	25′	1	.08	.14	.09
Drill	12′	1	.23	.34	.24
Swathing	12′	1	.20	.28	.21
Combine	6′ (12′ swath)	1	.39	1.20	.45
Totals			1.32	2.68	1.43

Source: Table 7.

Table 10. Labor and Fuel Requirements for Small Grain on Fall Plowing in East Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implements Kind	Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Plow	2-16″	1	1.00	2.00	1.05
Disk (single)	12′	1	.21	.36	.22
Harrow	25′	1	.08	.14	.09
Drill	12′	1	.23	.34	.24
Swathing	12′	1	.20	.28	.21
Combine	6′ (12′ swath)	1	.39	1.20	.45
Totals			2.11	4.32	2.26

Source: Table 7.

Tatble 11. Labor, Fuel Requirements for Small Grain on Spring Plowing in East Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Plow	2-16″	1	1.00	1.80	1.05
Harrow	25′	2	.16	.28	.18
Drill	12′	1	.23	.34	.24
Swathing	12′	1	.20	.28	.21
Combine	6′ (12′ swath)	1	.39	1.20	.45
Totals			1.98	3.90	2.13

Source: Table 7.

Table 12. Labor and Fuel Requirements for Small Grain on Fall Plowing in East Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Plow	3-14″	1	.70	1.75	.80
Disk (single)	15′	1	.17	.39	.18
Harrow	30′	1	.07	.14	.08
Drill	12′	1	.23	.41	.24
Swathing	12′	1	.20	.32	.21
Combine	12′ self prop.	1	.22	.82	.25
Totals			1.59	3.83	1.76

Source: Table 8.

Table 13. Labor and Fuel Requirements for Small Grain on Spring Plowing in East Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Implement Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Plow	3-14″	1	.70	1.75	.80
Harrow	30′	2	.14	.28	.16
Drill	12′	1	.23	.41	.24
Swathing	12′	1	.20	.32	.21
Combine	12′ self prop.	1	.22	.82	.25
Totals			1.49	3.58	1.66

Source: Table 8.

Table 14. Labor and Fuel Requirements for Small Grain Following Corn in East Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Implement Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Disk	15′	2	.34	.78	.36
Harrow	30′	1	.07	.14	.08
Drill	12′	1	.23	.41	.24
Swathing	12′	1	.20	.32	.21
Combine	12′ self prop.	1	.22	.82	.25
Totals			1.06	2.47	1.14

Source: Table 8.

Table 15. Labor, Fuel Requirements for Corn on Spring Plowing in East Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implement Kind	Implement Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Plow	2-16″	1	1.00	2.00	1.05
Harrow	25′	2	.16	.28	.18
Corn Planter	2-row	1	.43	.65	.45
Cultivator	2-row				
1st time		1	.38	.58	.40
2nd time		1	.34	.52	.36
3rd time		1	.31	.47	.32
Corn Picker	2-row	1	.55	.83	.63
Totals			3.17	5.33	3.39

Source: Table 7.

Table 16. Labor and Fuel Requirements for Corn on Fall Plowing in East Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implement		Times	Total Tractor Hrs.	Total Gals. Fuel	Total Man-Hrs.
Kind	Size	Over	Per A.	Per A.	Per A.
Plow	2-16″	1	1.00	2.00	1.05
Disk (single)	12′	1	.21	.36	.22
Harrow	25′	2	.16	.28	.1[illegible]
Corn Planter	2-row	1	.43	.65	.45
Cultivator	2-row				
1st time		1	.38	.58	.40
2nd time		1	.34	.52	.36
3rd time		1	.31	.47	.32
Corn Picker	2-row	1	.55	.83	.63
Totals			3.38	5.69	3.61

Source: Table 7.

tions were made for small grain on both spring and fall plowing. Also, calculations were made for small grains following corn. It requires more labor and fuel to raise small grains on fall plowing than either spring plowing or corn ground. These differences are shown in tables 9 through 14.

Corn. Similar calculations were made for corn. It was found that the tractor hours and man hours per acre were larger here on fall plowing because of the increased number of operations necessary in preparing the seed bed.

The labor and fuel requirements for corn are given in tables 15 and 16 for tractors in the 16 to 22 DBHP range and tables 17 and 18 for the tractors in the 23 to 27 DBHP range.

Forage Harvesting. Since complete information on haying operations was not secured during the survey of 1951, a large part of the power and machinery requirements for haying had to be secured from other studies (see footnotes to table 19).

Because the yield of hay per acre varies, not only annually, but by cuttings, it was believed best to prepare estimates for three different yields per cutting, namely, ½ ton, 1 ton, and 2 tons.

Labor estimates were prepared for the buckstacker, the automatic round baler, the automatic square baler (one man), and the field chopper.[6]

The time required to haul and store bales and silage (or chopped hay) was estimated separately from the baling or chopping. This permits adjustment for such things as the method of handling the bales and distance hauled. The haul was assumed to be one-half mile for wagons and buckstacker.

The man and tractor labor required for hauling the hay or silage

[6]Because of the current interest in grass silage the data are presented for ensiling the hay from the windrow. However, the data presented in USDA Circular 868 indicate that this data can also be used for chopped hay with slight adjustment. Only 0.1 hour or 6 minutes more time were required per ton for the silage as compared to the hay.

Table 17. Labor and Fuel Requirements for Corn on Spring Plowing in East Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Plow	3-14"	1	.70	1.75	.80
Harrow	30'	2	.14	.28	.16
Corn Planter	2-row	1	.43	.78	.45
Cultivator	2-row				
1st time		1	.38	.69	.40
2nd time		1	.34	.62	.36
3rd time		1	.31	.56	.32
Corn Picker	2-row	1	.55	1.00	.63
Totals			2.85	5.68	3.12

Source: Table 8.

Table 18. Labor and Fuel Requirements for Corn on Fall Plowing in East Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.
Plow	3-14"	1	.70	1.75	.80
Disk (single)	15'	1	.17	.39	.18
Harrow	30'	2	.14	.28	.16
Corn Planter	2-row	1	.43	.78	.45
Cultivator	2-row				
1st time		1	.38	.69	.40
2nd time		1	.34	.62	.36
3rd time		1	.31	.56	.32
Corn Picker	2-row	1	.55	1.00	.63
Totals			3.02	6.07	3.30

Source: Table 8.

Table 19. Man-Hours of Labor Per Ton of Forage Harvested and Stored According to Various Field Studies

Source	Buck-stackers	Automatic Round Baler	Automatic Square Baler	Bales Hauled and Stored	Silage* Field Chopper	Silage* Hauling and Storing
USDA Circ. 868†	1.0	0.5	0.5	1.5	0.3	.9
Idaho Circ. 120‡	0.7	0.3	0.5	1.7	.5	.7
Ill. Farm Econ. 216§	—	0.4	0.4	1.5	.3	.9
Data used in Table 20 for 1 ton yield	0.8	0.4	0.5	1.5	.3	.9

*The silage data are multiplied by 3 to put data on a more comparable basis with hay. The Idaho data are for chopped hay. It is assumed that one-fourth of the labor (1 man of 4-man crew) operates the chopper.
†R. E. Marx and James W. Berkhead. *Hay Harvesting Methods*. USDA Circ. 868. 1951. pp. 28. 44. 54. 58. Their data indicate (Table 10) that a ton of dry hay could be handled in 0.1 hours less time than 3 tons of silage.
‡Clyde B. Markeson. *Hay Harvesting. Time. Labor and Costs Vary with Harvesting Methods*. Idaho Agricultural Experiment Station Circular 120. 1952. Tables 1 and 2.
§J. E. Wills and R. E. Rogers. *Costs of Various Hay-Making Methods*, Illinois Farm Econ. No 216. June 1953.

Table 20.—Labor and Fuel Requirements for Haying Operations, per Cutting*

	Yield Per Cutting Ton	Man Hrs. Per A.	Tractor Hrs. Per A.	Gals. Fuel Per A.†
Mowing and Raking (7-ft. Swaths)	(All yields)	.7	.7	.7
Buckstacker (two men)	½	.4	.2	.4
	1	.8✓	.4	.7
	2	1.6	.8	1.4
Automatic Round Baler (PTO-one man)	½	.2	.2	.4
	1	.4✓	.4	.7
	2	.8	.8	1.4
Hauling and Storing of Dropped Bales (5 men, 3 tractors, 3 wagons, and bale loader)‡	½	.9	.6	1.1
	1	1.8	1.1	2.0
	2	3.6	2.2	4.0
Automatic Square Baler (PTO-one man)	½	.3	.3	.5
	1	.5✓	.5	.9
	2	1.0	1.0	1.8
Hauling and Storing of Loaded Bales (4 men, 2 tractors, 3 wagons—loaded behind baler)§	½	.8	.4	.7
	1	1.5✓	.8	1.4
	2	3.0	1.6	2.8
Field Chopper (PTO-one man)	½	.2	.2	.4
	1	.3✓	.3	.5
	2	.6	.6	1.1
Hauling and Storing of Chopped Forage (3 men, 2 tractors, 3 wagons—loaded behind chopper)	½	.5	.3	.5
	1	.9	.6	1.1
	2	1.8	1.2	2.2

*The data presented in this table are estimates derived from the data presented in Tables 7 and 19. Compare checked (✓) items with those of Table 19. Note that the data on grass silage are multiplied by 3 to make it directly comparable to other haying operations. Note also assumptions on raking in text.

†The gallons of fuel per acre are based on man-hours of labor. Since the tractor will operate perhaps 10 percent less time the fuel calculated from this table should be reduced about 10 percent. The fuel consumpiton is assumed to be 1.8 gallons per hour (except for mowing and raking).

‡Without the bale loader another man would be necessary to load the wagon but little time would be saved. See USDA Circ. 868, p. 57.

§Includes a man on the wagon being pulled by the baler.

from the field to the place of storage is assumed to be directly proportional to the yield, whether done by buckstacker or wagon. That is, for a given field and field condition doubling the yield per acre will double the trips and storage labor required. Fuel charges would also be directly proportional.

Slightly less labor *per ton* would be required to set up equipment when the yield is high than when it is low since there would be more tons over which such "overhead" labor could be spread. These costs appeared to be so small as to defy estimation on a per ton basis and would not affect *per acre* costs.

The baling and forage chopper performance is also directly proportional to the amount of hay produced per acre per cutting when it is assumed that mower swaths were made into windrows as follows:

Yield Per Cutting (T/A)	Swaths Per Windrow	Relative No. Windrows Per Given Field
½	4	1
1	2	2
2	1	4

Thus, because the number of windrows are directly proportional to the yield of forage, the high priced baling and chopping equipment could be used at or near its optimum capacity. The rates of performance are then directly proportional to the yield of hay.

Tractors used were assumed to be of 23-27 DBHP rating and to consume 1.8 gallons of fuel per hour of operations, except for mowing and raking, where 16-22 horsepower tractors were assumed.

Future investigations will no doubt produce data which will improve these estimates. Meanwhile, these estimates may be of help to those who must make decisions on the basis of data now available.

Performance for Selected Irrigation Operations

A part of east central South Dakota, the Oahe area along the James River, is being considered for irrigation. It is important, therefore, that an attempt be made to estimate some of the rates of performance that would exist under these conditions in this area. These physical data are presented so they might be used as a guide in budgeting and planning farm costs for irrigation in the areas in which it has been proposed. Besides that based on the 1951 time study survey, information has been taken from other studies in areas considered to be similar to that of the Oahe area in soil, climate, and rainfall.

RATES OF PERFORMANCE ON DRYLAND AND IRRIGATED LAND

There are a number of factors which bring about differences in rates of performance on dryland and irrigated land. Some of these factors are as follows: (1) machinery and implements used under irrigation are, in most cases, smaller than those used on dryland operations; (2) fields under irrigation are usually much smaller than fields on dryland farming; (3) the number of operations necessary for producing comparable crops on dryland and irrigated land is greater under irrigation; (4) irrigating the land itself requires a large number of man-hours per acre.

Thus, it will be shown that the above conditions have a great deal of influence on rates of performance and labor requirements.

CALCULATIONS OF RATES OF PERFORMANCE FOR IRRIGATION

The calculations on rates of performance were made for fields of three different lengths. These field lengths were based on standards set up by the Bureau of Reclamation. The size of implements used in the calculations were based in part on an unpublished study of the Lower Yellowstone conducted by the North Dakota State Agricultural College in cooperation with the BAE.[7] Machine sizes were also selected on the basis of standards set up by the Bureau of Reclamation for the Oahe area.

[7]Unpublished study on management practices and yields in Lower Yellowstone, North Dakota Agricultural Experiment Station, Agriculturalp Economics Department, in cooperation with the BAE.

The speed of travel used in calculating rates of performance under irrigated conditions is the same as that used for dryland operations. Because of deeper tillage and different soil conditions, implements of comparable size will commonly require more power on irrigated land than on dryland. Therefore, in using the same equipment on irrigated land as on dryland, the speed of travel would be decreased. But, since smaller equipment is being used on irrigated farms, the same rate of speed was assumed to be used as on dryland.

The time lost per hour is assumed to be the same as on dryland operations. The time required for turning on ends was increased from 20 to 40 seconds, since more care would probably be taken on a limited irrigated acreage. Burdick's equation was used in making the calculations.

Results of the calculations of rates of performance are shown in tables 21, 22, and 23.

SMALL GRAIN, CORN, POTATO, AND SUGAR BEET REQUIREMENTS

In setting up the total labor and fuel requirements, it was necessary to make a decision on what crops might be raised under irrigation in the Oahe area. The main crops chosen were small grain, corn, potatoes, hay, and sugar beets. These are considered the most important, although it is likely that other crops will be raised.

The next step was to determine the number of operations necessary for producing and harvesting the crop; and also, the number of times each operation must be performed.

The necessary operations and number of times each operation was performed were based on the Yellowstone study. This study was used because this area compares favorably with conditions that exist in the Oahe area in regard to soil and rainfall. The labor and fuel requirements for different operations were taken from the rates of performance given in tables 21, 22, and 23.

The total requirements per acre have been set up on the basis of three different field lengths. These field lengths are the same as those that were used in calculating rates of performance. This was done to show differences in labor and fuel requirements for different length fields and also because it was assumed that these lengths would be typical of fields set up on the Oahe area.

Small Grain. Some small grains are generally grown by farmers in irrigated areas. It is, therefore, desirable to estimate the rates of performance for the various operations involved in raising these crops under irrigation.

Operations for raising oats, barley, and wheat are all somewhat similar and, therefore, they have all been put together under the heading of small grains. Generally, the operations for preparing the land are plowing, disking, harrowing, and seeding with a grain drill. Irrigated land also requires such operations as leveling, corrugating, and irrigating, which make the labor requirements considerably higher for

Table 21. Estimated Rates of Performance and Fuel Consumption for Operation on Irrigated Land—Field Length 30 Rods

Implement: Kind	Implement: Size*	Speed (MPH)	Min. Lost Per Hr.	Hrs. Per A.†	Gals. Fuel Per Hr.	Gals. Fuel Per A.
Plow	2-14″	4.0	5	1.22	1.9	2.32
Disk-Tandem	8′	4.0	5	.44	2.0	.88
Harrow	15′	4.5	5	.22	1.5	.33
Cultivator	2-row					
1st time		3.5	5	.53	1.4	.74
2nd time		4.0	5	.50	1.4	.70
3rd time		4.5	5	.45	1.4	.63
Drill	8′	4.0	10	.49	1.5	.74
Corn Planter	2-row	4.0	15	.58	1.5	.87
Side Delivery	8′	4.5	5	.40	1.0	.40
Mower	7′	4.5	5	.47	1.0	.47
Swather	8′	4.5	5	.40	1.4	.56
Combine	6′ (8′swath)	2.5	10	.66	3.0	1.98
Combine Straight	6′	3.0	10	.65	3.0	1.95
Corn Picker	1-row	3.0	15	1.41	1.8	2.54
Corn Picker	2-row	3.0	15	.61	1.8	.92
Field Chopper	1-row	3.0	15	1.41	1.8	2.54
Potato Planter	2-row	2.5	30	.96	2.0	1.88
Cultivator	2-row					
1st time		3.0	5	.61	1.9	1.13
2nd time		3.5	5	.53	1.9	.98
Other		4.0	5	.50	1.9	.92
Sprayer	6-row	4.0	15	.19	1.3	.25
Stalk Cutter	2-row	3.5	5	.53	1.9	.98
Leveler	8′	3.5	5	.45	1.7	.77
Potato Digger	1-row	2.5	10	1.50	2.2	3.24
Potato Digger	2-row	2.5	10	.75	2.5	1.88
Beet Planter	4-row	2.5	15	.80	1.3	1.07
Ditcher	4-row	4.0	5	.50	1.9	.92
Beet Cultivator	4-row					
1st time		2.5	5	.69	1.9	1.32
2nd time		3.0	5	.61	1.9	1.17
Other		3.5	5	.53	1.9	1.02
Beet Harvester	1-row	3.0	15	2.74	1.9	5.26
Beet Harvester	2-row	3.0	15	1.41	2.2	3.05

*Rows for sugar beets are 20 inches apart. Potatoes, same as for corn.
†40 seconds allowed for turning on ends. Drawbar horsepower of tractor, 16-22.

Sources:

The Economics of Sugar Beet Mechanization, Colorado Agricultural Experiment Station Bulletin 411-A, April 1950.

Crop Labor Requirements and Seasonal Distribution—Oahe Area, Repayment Unit, Economics and Repayment Section, Bureau of Reclamation, April 1951.

"Input and Output Data for Principal Crops on Selected Irrigated Soils, Tri-County and Platte Valley Area, Central Nebraska," South Dakota Experiment Station (mimeographed preliminary), April 1951.

Table 22. Estimated Rates of Performance and Fuel Consumption for Operation on Irrigated Land—Field Length 21 Rods

Implement Kind	Size*	Speed (MPH)	Min. Lost Per Hr.	Hrs. Per A.†	Gals. Fuel Per Hr.	Gals. Fuel Per A.
Plow	2-14″	4.0	5	1.40	1.9	2.66
Disk-Tandem	8′	4.0	5	.49	2.0	.98
Harrow	15′	4.5	5	.24	1.5	.36
Cultivator	2-row					
1st time		3.5	5	.61	1.4	.85
2nd time		4.0	5	.57	1.4	.80
3rd time		4.5	5	.52	1.4	.73
Drill	8′	4.0	10	.55	1.5	.83
Corn Planter	2-row	4.0	15	.65	1.5	.98
Side Delivery	8′	4.5	5	.46	1.0	.46
Mower	7′	4.5	5	.53	1.0	.53
Swather	8′	4.5	5	.46	1.4	.64
Combine	6′ (8′ swath)	2.5	10	.72	3.0	2.16
Combine Straight	6′	3.0	10	.70	3.0	2.10
Corn Picker	1-row	3.0	15	1.56	1.8	2.80
Corn Picker	2-row	3.0	15	.65	1.8	.98
Field Chopper	1-row	3.0	15	1.56	1.8	2.80
Potato Planter	2-row	2.5	30	1.05	2.0	2.06
Cultivator	2-row					
1st time		3.0	5	.68	1.9	1.26
2nd time		3.5	5	.61	1.9	1.13
Other		4.0	5	.57	1.9	1.05
Sprayer	6-row	4.0	15	.22	1.3	.29
Stalk Cutter	2-row	3.5	5	.61	1.9	1.13
Leveler	8′	3.5	5	.50	1.7	.86
Potato Digger	1-row	2.5	10	1.67	2.2	3.61
Potato Digger	2-row	2.5	10	.82	2.5	2.05
Beet Planter	4-row	2.5	15	.88	1.3	1.18
Ditcher	4-row	4.0	5	.57	1.9	1.05
Beet Cultivator	4-row					
1st time		2.5	5	.76	1.9	1.46
2nd time		3.0	5	.68	1.9	1.31
Other		3.5	5	.61	1.9	1.17
Beet Harvester	1-row	3.0	15	3.04	1.9	5.84
Beet Harvester	2-row	3.0	15	1.56	2.2	3.37

*Rows for sugar beets are 20 inches apart. Potatoes, same as for corn.
†40 seconds allowed for turning on ends. Drawbar horsepower of tractor, 16-22

Source:

The Economics of Sugar Beet Mechanization, Colorado Agricultural Experiment Station Bulletin 411-A, April 1950.

Crop Labor Requirements and Seasonal Distribution—Oahe Area, Repayment Unit. Economics and Repayment Section, Bureau of Reclamation, April 1951.

"Input and Output Data for Principal Crops on Selected Irrigated Soils, Tri-County and Platte Valley Area, Central Nebraska," South Dakota Experiment Station (mimeographed preliminary), April 1951.

Table 23. Estimated Rates of Performance and Fuel Consumption for Operation on Irrigated Land—Field Length 14 Rods

Implement Kind	Size*	Speed (MPH)	Min. Lost Per Hr.	Hrs. Per A.†	Gals. Fuel Per Hr.	Gals. Fuel Per A.
Plow	2-14″	4.0	5	1.66	1.9	3.15
Disk-Tandem	8′	4.0	5	.52	2.0	1.04
Harrow	15′	4.5	5	.28	1.5	.42
Cultivator	2-row					
1st time		3.5	5	.72	1.4	1.01
2nd time		4.0	5	.68	1.4	.95
3rd time		4.5	5	.63	1.4	.88
Drill	8′	4.0	10	.66	1.5	.99
Corn Planter	2-row	4.0	15	.78	1.5	1.17
Side Delivery	8′	4.5	5	.56	1.0	.56
Mower	7′	4.5	5	.65	1.0	.65
Swather	8′	4.5	5	.56	1.4	.78
Combine	6′ (8′ swath)	2.5	10	.77	3.0	2.31
Combine Straight	6′	3.0	10	.76	3.0	2.28
Corn Picker	1-row	3.0	15	1.82	1.8	3.28
Corn Picker	2-row	3.0	15	.75	1.8	1.12
Field Chopper	1-row	3.0	15	1.82	1.8	3.28
Potato Planter	2-row	2.5	30	1.20	2.0	2.35
Cultivator	2-row					
1st time		3.0	5	.78	1.9	1.44
2nd time		3.5	5	.72	1.9	1.33
Other		4.0	5	.68	1.9	1.26
Sprayer	6-row	4.0	15	.26	1.3	.35
Stalk Cutter	2-row	3.5	5	.72	1.9	1.33
Leveler	8′	3.5	5	.60	1.7	1.03
Potato Digger	1-row	2.5	10	1.92	2.2	4.15
Potato Digger	2-row	2.5	10	.94	2.5	2.35
Beet Planter	4-row	2.5	15	1.00	1.3	1.30
Ditcher	4-row	4.0	5	.68	1.9	1.26
Beet Cultivator	4-row					
1st time		2.5	5	.87	1.9	1.67
2nd time		3.0	5	.78	1.9	1.50
Other		3.5	5	.73	1.9	1.40
Beet Harvester	1-row	3.0	15	3.54	1.9	6.80
Beet Harvester	2-row	3.0	15	1.82	2.2	3.93

*Rows for sugar beets are 20 inches apart. Potatoes, same as for corn.
†40 seconds allowed for turning on ends. Drawbar horsepower of tractor, 16-22

Source:

The Economics of Sugar Beet Mechanization, Colorado Agricultural Experiment Station Bulletin 411-A, April 1950.

Crop Labor Requirements and Seasonal Distribution—Oahe Area, Repayment Unit, Economics and Repayment Section, Bureau of Reclamation, April 1951.

"Input and Output Data for Principal Crops on Selected Irrigated Soils, Tri-County and Platte Valley Area, Central Nebraska," South Dakota Experiment Station (mimeographed preliminary), April 1951.

irrigated land than dryland. In comparing the labor requirements for producing small grain on irrigated land and on dryland, it is found that it requires three times as many man-hours to produce an acre of small grain under irrigation as it does to produce an acre of small grain on dryland. The estimated requirements for producing small grain under irrigation are shown in table 24.

Corn. Corn is a popular crop in irrigated areas, and would be quite important in the Oahe area. The operations for producing corn on dryland and irrigated land are somewhat similar except that the operations, in most cases, are more intense under irrigation. In addition, such operations as leveling, ditching, and irrigating must be included. In a comparison of the labor requirements for producing corn on irrigated land and on dryland, it is found that almost three times as many man-hours are required on irrigated land as on dryland. The estimated requirements for producing corn under irrigation are shown in table 25.

Sugar Beets. Sugar beets are an important source of cash income in many irrigated areas.

Plowing is usually the first operation in preparing the land for sugar beets, but sometimes plowing is preceded by disking. Following the plowing, the land is usually worked down with disks and harrows. Leveling is another operation that is necessary. There is also a great amount of hand labor connected with raising the sugar beets, such as irrigating, hoeing, and thinning. In some areas the mechanical thinner is being used, but, as yet, a greater percentage of the thinning is done by hand.

Harvesting of sugar beets has be-

Table 24. Estimated Labor and Fuel Requirements for Small Grain in Proposed Irrigation Areas in East Central South Dakota, 1950

Implement			Length of Field 30 Rods			Length of Field 21 Rods			Length of Field 14 Rods		
Kind	Size	Times Over	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*
Plow	2-14″	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disk-Tandem	8′	1	.44	.86	.46	.49	.98	.51	.51	1.04	.54
Harrow†	15′	2	.44	.66	.46	.48	.72	.50	.56	.84	.58
Leveler	8′	2	.90	1.54	.94	1.00	1.06	1.06	1.20	2.06	1.26
Drill	8′	1	.49	.74	.52	.55	.83	.58	.66	.99	.69
Irrigate‡		2	—	—	2.60	—	—	2.60	—	—	2.60
Clean Ditches‡		—	—	—	.10	—	—	.10	—	—	.10
Swather	8′	1	.40	.56	.58	.46	.64	.48	.56	.78	.59
Combine	6′	1	.66	1.98	.76	.72	2.16	.87	.77	2.31	.81
Total			4.55	8.66	7.70	5.10	9.05	8.17	5.92	10.47	8.41

*Man-hours for hauling not included.
†Labor and fuel requirements for corrugating, same as that for harrow or cultivator of the same size.
‡Labor requirements for irrigation and cleaning ditches were taken from an unpublished study on on management practices for yields in Lower Yellowstone, made by the North Dakota Agricultural College in cooperation with the BAE.

come largely mechanized. This mechanization of sugar beet harvest has cut down considerably the hand labor and the amount of man-hours required to produce an acre of sugar beets.

The estimated labor requirements for the production of sugar beets in the Oahe area are given in table 26.

Potatoes. The preparation of the land for potatoes does not differ greatly from that of sugar beets. Most of the operations are the same except that thinning is not required in the production of potatoes, so that less labor is necessary. In general, the total labor requirements per acre for potatoes are considerably lower than those for sugar beets. The estimated labor and fuel requirements for producing an acre of potatoes are given in table 27.

Nothing has been said about labor and fuel requirements for alfalfa. The requirements for harvesting alfalfa were calculated and they may be found by referring to table 20. The preharvest operations and requirements are similar to those for small grain under irrigation except when seeded in small grain. When seeded in small grain, very little labor is required in addition to that applied to the small grain.

All of the labor and fuel requirements have been calculated for the important operations except hauling the produce at harvest time. This was not done because of the variations that exist because of items such as yields, distance hauled, and method used in hauling. There is no information available and a study has not been made on the time requirements for this operation.

Table 25. Estimated Labor and Fuel Requirements for Corn in Proposed Irrigation Areas in East Central South Dakota, 1950

Implement			Length of Field 30 Rods			Length of Field 21 Rods			Length of Field 14 Rods		
Kind	Size	Times Over	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*
Plow	2-14"	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disk-Tandem	8′	2	.88	1.76	.92	.98	1.96	1.03	1.04	2.08	1.09
Harrow	15′	3	.58	.88	.62	.64	.96	.68	.74	1.12	.78
Leveler	8′	1	.45	.77	.52	.55	.83	.58	.66	.99	.69
Planter	2-row	1	.58	.87	.61	.65	.98	.68	.78	1.17	.82
Cultivator	2-row	4	1.90	2.70	2.00	2.22	3.16	2.33	2.66	3.72	2.79
Irrigate†		4	—	—	4.27	—	—	4.27	—	—	4.27
Clean Ditches†		1	—	—	.10	—	—	.10	—	—	.10
Picker	2-row	1	.61	.92	.70	.65	.98	.75	.75	1.12	.86
Field Chopper	1-row	1	1.41	2.54	1.62	1.56	2.80	1.79	1.82	3.28	2.07
Sprayer‡	2-row	1	.45	.63	.47	.52	.73	.55	.63	.88	.66
Total			8.08	13.39	13.11	9.17	15.06	14.23	10.74	17.51	15.87

*Man-hours for hauling not included.

†Labor requirements for irrigation and cleaning ditches were taken from an unpublished study on management practices and yields in Lower Yellowstone made by the North Dakota Agricultural College, in cooperation with the BAE.

‡Spraying for corn borers is figured at the same rate as the third cultivation.

Monetary Costs of Operations

Since the preceding data on power and machinery performance have been given in physical terms, they must be converted into monetary terms to be used in setting up farm budgets. This will, of course, involve using current or projected prices of fuel and equipment, together with additional pertinent information.

Cost of operating farm machinery can be divided into two main categories, variable and fixed. Variable costs, such as fuel, oil, and grease, are directly dependent on the amount of use. The cost of fuel for any operation can be computed by simply multiplying the number of gallons of fuel required by the price per gallon. The cost of oil and grease will average approximately one-sixth that of fuel.

Repair costs, while varying with use, are difficult to predict, since they are dependent on the kind and quality of machine and the care used in operation and maintenance, as well as the hours of operation. The average cost per hour of operation for a tractor has been estimated to be .007 percent of the original cost of the machine. This would, for example, be 14 cents per hour for a $2,000 tractor.[8]

For other machines, a range of from 2 to 4 percent of the original cost annually has been estimated.[9]

Fixed or overhead costs, on the other hand, go on regardless of use, and can only be considered when deciding whether or not to purchase a machine. The average cost per hour of operation will, of course, be dependent upon the amount of use, but additional use will not result in added costs. For a machine already owned, these costs cannot be considered. Costs which are strictly fixed include taxes, interest, and insurance. Since the average value of a machine over its useful life is one-half of its original cost, those charges should be computed on this amount.

Depreciation might be expected to be dependent mainly on the amount a machine is used, but because of obsolescence, weathering, and the desirability of recovering the original cost within a reasonable period of time, it is largely a fixed cost. Fifteen years is a fair approximation of the useful life of most machines, with 12 years for corn pickers and hay balers and 10 years for combines.[10]

The annual depreciation can, therefore, be estimated at 1/15, 1/12, and 1/10 of the original cost, respectively. For tractors, a formula has been worked out involving both a fixed factor for obsolescence and a variable factor for wear and tear. In general, the fixed component will be approximately 9 percent of the

[8] "Base Prices for Long-Term Farm Budgets in South Dakota," South Dakota Agricultural Experiment Station, Agricultural Economics Pamphlet 51, February 1954.

[9] Robert Finley, *Fitting Power and Machinery to the Farm,* Department of Agricultural Economics, University of Illinois, College of Agriculture, Urbana, Illinois, AE 3082, November 18, 1955.

[10] "Base Prices for Long-Term Farm Budgets in South Dakota," op. cit.

Table 26. Estimated Labor and Fuel Requirements for Sugar Beets in Proposed Irrigation Areas in East Central South Dakota in 1950

Implement			Length of Field 30 Rods			Length of Field 21 Rods			Length of Field 14 Rods		
Kind	Size	Times Over	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*
Plow	2-14"	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disk-Tandem	8'	2	.88	1.76	.92	.98	1.96	1.03	1.04	2.08	1.74
Harrow	15'	3	.66	.99	.69	.72	1.08	.78	.84	1.26	.88
Leveler	8'	2	.90	1.54	.95	1.00	1.72	1.05	1.20	2.06	1.26
Planter	4-row	1	.80	1.07	.84	.88	1.18	.92	1.00	1.30	1.05
Cultivator	4-row	4	2.36	4.53	2.47	2.66	5.11	2.79	3.11	5.97	3.27
Thin by hand†		1	—	—	5.00	—	—	5.00	—	—	5.00
Ditcher†		1	—	—	.47	—	—	.47	—	—	.47
Hoe by hand†		—	—	—	7.35	—	—	7.35	—	—	7.35
Pull, top, load†		1	3.70	3.70	4.48	4.00	4.00	4.98	4.45	4.45	5.43
Irrigate‡		5	—	—	7.00	—	—	7.00	—	—	7.00
Total			10.52	15.91	31.45	11.64	17.71	32.84	13.30	20.27	34.54

*Man-hours for hauling not included.
†Labor requirements for thinning, ditching, hoeing, and harvesting were taken from *Crop Production Practices in Great Plains*, USDA, BAE, Washington, D. C., 1953.
‡Labor requirements taken from an unpublished study on management practices and yields in Lower Yellowstone, made by the North Dakota Agricultural College in cooperation with the BAE.

Table 27. Estimated Labor and Fuel Requirements for Potatoes in Proposed Irrigation Areas in East Central South Dakota in 1950

Implement			Length of Field 30 Rods			Length of Field 21 Rods			Length of Field 14 Rods		
Kind	Size	Times Over	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*	Total Tractor-Hrs. Per A.	Total Gals. Fuel Per A.	Total Man-Hrs. Per A.*
Plow	2-14"	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disk-Tandem	8'	2	.88	1.76	.92	.98	1.96	1.03	1.04	2.08	1.09
Harrow	15'	3	.66	.99	.69	.72	1.08	.78	.84	1.26	.88
Leveler	8'	1	.45	.77	.47	.50	.86	.52	.60	1.03	.63
Planter	2-row	1	.96	1.88	1.00	1.05	2.06	1.10	1.20	2.35	1.26
Cultivator	2-row	3	1.64	3.03	1.68	1.86	3.44	1.92	2.18	4.03	2.25
Sprayer	6-row	3	.57	.75	.60	.66	.87	.69	.78	1.05	.81
Ditcher†		1	—	—	.47	—	—	.47	—	—	.47
Irrigate‡		4	—	—	5.60	—	—	5.60	—	—	5.60
Roto-Beater	2-row	1	.53	.98	.55	.61	1.13	.64	.72	1.33	1.37
Potato Digger	1-row	1	1.50	3.24	1.58	1.67	3.61	1.75	1.92	4.15	2.02
Total			8.41	15.72	14.84	9.45	17.67	15.97	10.94	20.43	18.12

*Man-hours for hauling not included.
†Labor requirements for ditching were taken from *Crop Production Practices in Great Plains*, USDA, BAE, Washington, D. C., 1953.
‡Labor requirements taken from an unpublished study on management practices and yields in Lower Yellowstone, made by the North Dakota Agricultural College in cooperation with the BAE.

original cost annually, while the variable component will be approximately .005 percent of the original cost, per hour of operation. On a $2,000 tractor, this would be $180 annually, plus 10 cents per hour of operation.[11]

In contemplating an enterprise requiring additional machinery, or in comparing the cost of owning a machine with that of custom work, fixed as well as variable costs must be considered. In considering an enterprise using equipment already on hand, however, only the variable costs can be allowed to enter in.

EXAMPLE 1. A farmer with 100 acres of small grain on dryland and a 20 H.P. tractor is contemplating the purchase of a 6-foot combine, as an alternative to having his crop custom-combined. Consulting table 7, he finds that using such a machine with his tractor will involve 39 tractor hours and 120 gallons of fuel. If the combine is priced at $2,100, his tractor cost $2,000 new, and fuel sells for 20 cents per gallon, he can estimate his annual power and machine costs as follows:

Variable costs	
Fuel—120 gal. x 20 cents per gal.	$ 24.00
Grease and oil—⅙ x $24.00	4.00
Tractor repairs—39 hrs. x .007% per hr. x $2,000	5.46
Tractor depreciation—39 hrs. x .005% per hr. x $2,000	3.90
Combine repairs—2% x $2,100	42.00
Total Variable Costs	$ 79.36
Fixed Costs	
Combine depreciation—1/10 x $2,100	$210.00
Interest—5% x $\frac{\$2,100}{2}$	52.50
Taxes (@ 25 mills x $300 average assessed valuation)	7.50
Insurance (Based on minimum policy)	10.00
Total Fixed Costs	$280.00
Total Power and Machine Costs	$369.36

In addition, of course, there is the cost of labor for operating. In this case, 45 hours would be required (table 9). If extra labor must be hired, or regular labor must be diverted from some other productive use, this cost must be included in making a comparison with the cost of custom work.

EXAMPLE 2. The farmer has purchased the combine and now contemplates increasing his small grain acreage from 100 acres to 200 acres. Now, in computing his additional power and machinery costs, he can consider only the variable costs. The total cost, exclusive of labor, of combining the extra 100 acres would, therefore, be only $79.36 (total variable cost) since his fixed costs would already have been incurred and would not be increased.

[11]Ibid.