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FARM LABOR, POWER AND MACHINERY PERFORMANCE

FOR SELECTED OPERATIONS UNDER

DRYLAND AND IRRIGATED CONDITIONS IN

CENTRAL SOUTH DAKOTA

by

James A. Ulvilden

Bachelor of Arts Degree at Luther College, 1947

A Thesis

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of

The South Dakota State College

of

Agriculture and Mechanic Arts

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In Partial Fulfillment of the Requirements

For the Degree of Master of Science

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FARM LABOR, POWER AND MACHINERY PERFORMANCE FOR SELECTED OPERATIONS UNDER DRYLAND AND IRRIGATED CONDITIONS IN CENTRAL SOUTH DAKOTA

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James A. Ulvilden

This thesis is approved as a creditable independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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CHAPTER I

INTRODUCTION

The problems of farm managers are everlasting. They are constantly in the process of examining alternative methods of production and alternative combinations of resources in an attempt to attain a higher and more stable income.

For this farm planning, a vast amount of physical data on the cost and returns of alternative plans is needed. It is important that the physical data be as accurate as possible, because the farm plan is no better than the information upon which it is based.

Technological progress has been very rapid in agriculture and thus it is important to keep up with changes that are taking place. It is necessary that labor, power and machinery requirements are adjusted to the progressive development in agriculture. Power and machinery costs represent a large part of the total costs of producing small grains and intertilled crops; therefore, the farm manager is very much interested in his machinery, his power needs and their most economical management and use.

A. Statement of the Problem

A serious problem in farm planning is the lack of information on labor, power and machinery required for different farming enterprises, and combinations of enterprises, in central South Dakota.

A certain minimum of power, machinery and labor is necessary for successful farm operation. Before this minimum can be determined,

there are a number of problems which the farm manager must consider.

1. What are the power needs and what type of equipment is necessary to go with these power needs? Power resources are in a continual process of being adapted to changes in equipment. To some extent this process is a two-way adjustment. The existing source of power influences the choice and selection of new equipment; and in the same way, the present line of equipment influences the selection of the power.

2. How does the labor supply fit in with the machinery and power being used? If there is a shortage of labor, labor saving machinery may be necessary; but if there is an abundance of labor, the investment in machinery may be smaller.

3. What portion of the farm operations should be custom hired?

4. What are the conditions of soil, nature of topography, and size of fields? These factors will be important in influencing the choice of power and equipment.

5. What are the interests and capabilities of the farm manager, himself?

6. How much capital does the farmer have available?

These problems make it desirable to provide information which will help determine the best use of labor, power and machinery necessary for different farming enterprises and also, to provide a basis for determining costs of operation.

B. Purpose of Study

The purpose of this study is to determine labor, power and machinery rates of performance for different farming operations in

central South Dakota, for both dryland and irrigated conditions.

The operations on which information will be presented will be those that are most typical of this area. These operations will include such field operations as are necessary for producing and harvesting small grain, corn and hay in both dryland and irrigated areas. The individual operations will be dealt with later in the study.

Since the costs for these different operations vary from year to year, and vary between farms, depending on size and organization, they are presented in physical terms rather than in monetary terms. When presented in this manner, the specific costs for a particular farm can be determined by attaching current prices to the physical quantities.

C. Procedure Used in This Study

In setting up the procedure for this study, it was decided that rates of performance for different machines would be calculated, using an equation developed by Burdick. 1/ In order to use this equation, it was necessary to conduct a time study to secure data for the equation. This survey was made in 1951. The information on sizes and types of machines was taken from an unpublished study made in the Oahe area in 1950 by the Agricultural Economics Department and Experiment Station at South Dakota State College.

Explanation of Burdick's Equation.—Burdick's equation and his explanation are as follows:

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

1/ R. T. Burdick, A New Technique for Field Crop Labor Analysis, Colorado Agricultural Experiment Station, Tech. Bul. 36, June 1949.

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 2/3 per cent of the 8.25 hours required for straight work at a one-mile speed. But 6 and 2/3 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 1/2 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.

Method Used and Data Obtained in the 1951 Survey.—The data presented is based on a survey made in the summer of 1951. The survey consisted of contacting farmers and timing the different field operations for a period of one hour.

The schedules for this survey were taken in the sub-areas of the proposed Oahe irrigation area which was being considered for irrigation in 1950. The sub-areas in central South Dakota are as follows:

Huron - Redfield area
Miller - Vayland area
Redfield - Mellette area
Huron - Woonsocket area
Faulkton - Cresbard area

These areas are shown on the map (Figure 1).

The method used in selecting the farmers to be contacted was to send the person taking the schedules into one of the five areas to time any operations which were being carried on there. If he was seeking information on cultivating, for example, he would drive along the road and whenever he came to someone cultivating corn, he would stop and time his operation. The same procedure was used for other operations. This procedure for picking the farms seemed better than determining the farms to be contacted before going out in the field, because there was no way

of knowing definitely when these farmers would be performing the different operations.

Two hundred five schedules were taken in this area of 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. The information presented on other operations is based on data obtained on those mentioned above (for sample copy of schedule, refer to appendix).

Information Obtained from 1950 Oahe Survey.—The data presented in this study on typical machines, and sequence and number of operations, were taken from an unpublished study made in the Oahe area in 1950 by the Agricultural Economics Department, South Dakota Agricultural Experiment Station. The information in the 1950 study was obtained by interviewing individual farmers in areas selected by a random method in the proposed Oahe irrigation area (see Figure 1).

Sources of Irrigation Data.—Information on irrigation was also calculated by using Burdick's equation. The data for the equation were based, in part, on the 1951 survey in central South Dakota, 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,

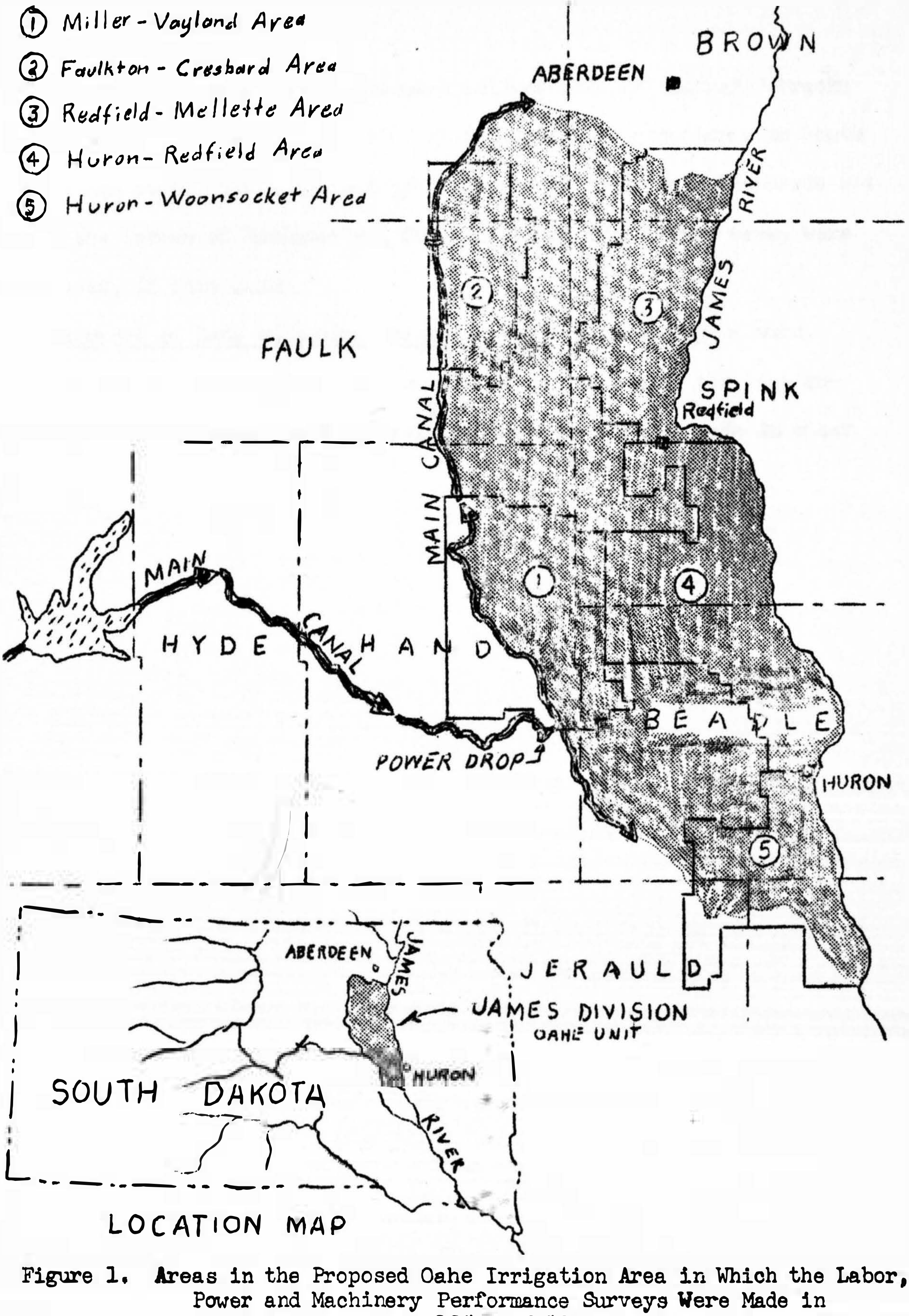

Figure 1. Areas in the Proposed Oahe Irrigation Area in Which the Labor, Power and Machinery Performance Surveys Were Made in 1950 and 1951

were based on studies of irrigation practices made in central Nebraska and the Lower Yellowstone in 1950, by the BAE in cooperation with South Dakota and North Dakota Agricultural Experiment Stations. Standards set up by the Bureau of Reclamation, for irrigation in the Oahe area, were also used, in some cases.

Sources of Data on Haying Operations.—No data on haying were secured in the 1951 survey. The data used in developing the requirements for haying were based entirely on previous studies made in other states.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to review, critically, available labor, power and machinery input-output data suitable for South Dakota; thus, making it clear why this study was needed and what it contributes to the field of input data.

There have been no recent studies published showing labor, power and machinery rates of performance for different farming operations in central South Dakota. The most recent surveys are those used in this particular study.

There are four main methods that can be used in making studies of this nature. They may be classified as follows: experimental studies, studies based on farm records, studies based on interviews with the farmer and studies based on the timing of operations.

Most of the studies that have been made in other states were made by the interview method, in which the farmers estimated the time required for various operations. Others were based on records that had been kept by farmers over a period of years. Studies based on timing of different operations have been less frequent.

Studies that have been made in South Dakota will be considered first and then studies that have been made in other states will follow.

Hampson and Christopherson made a study of tractor and horse power in Potter County, South Dakota in 1930. 1/ The purpose of this study was to make information available which would aid farmers in deciding

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1/ 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.

under what circumstances it was more economical to use tractor or horses or a combination of both.

The information for the study was obtained from daily records kept by farm operators, with the assistance of a regular field agent at regular monthly intervals.

Much of the data presented in this study are out of date at the present time because of the changes that have taken place in tractor power, and the fact that horses are no longer used enough to be of any importance.

This being the only study of its kind published for South Dakota since 1930, it is desirable that data of this nature be brought up to date. This study, however, will not be concerned with the advantages of horse power and tractor power; it will be concerned with the efficient use of tractor power, labor and machinery.

Miller, Quentin and George presented a study on the cost of operating machinery on Nebraska farms. 2/ This survey was made in Cass, Cheyenne, Kearney, Lancaster, Scotts Bluff and Washington counties during the summer of 1947.

The information and data, in this study, were acquired by interviewing farm operators. The rates of performance were obtained by dividing the average number of acres of annual use reported by the operators, by the average hours they spend doing the work. It would be very difficult for farmers to give an accurate estimate of this nature unless they were diligently keeping a record of the time required

2/ Frank Miller, et al., Cost of Operating Machinery on Nebraska Farms, Nebraska Agricultural Experiment Station Bulletin 391, 1948.

for the various operations.

An equation for calculating rates of performance was used in this study, but in most instances, the rate of performance obtained from the data reported by farm operators was somewhat higher than the rate calculated by formula. It was thought that this difference was due to the fact that in the calculated values, no allowance was made for time lost in stops for greasing, for adjusting the machine and for turning on ends. The speed at which the machine was drawn was assumed; it was not actual speed.

Another study that should be mentioned is one conducted by Burdick, whereby, he introduces a new technique of field crop labor analysis. 3/

This study was a shift from analysis of historical crop data to a more theoretical general purpose analysis. The reason for the shift arose from the fact that historical data caused one to look backward in all matters of analysis, while the actual conditions under which crops are produced are changing, requiring a constant looking ahead and forecasting of the effects of proposed changes. The time required to secure field data, to analyze them, and to put them in useful condition meant that a new practice was being tried by the time one had knowledge from the analysis of the old.

This study tends to emphasize the theoretical aspects of farm management. The theory of farm management may be likened to the theory of the firm, in that individual decisions are made by owner operators. Theory here refers to what should happen under the assumed conditions in the absence of unexpected obstacles.

3/ Burdick, op. cit.

The chief problem here was to find some method of analyzing farm operations before they were performed, instead of waiting until the work was done, and securing a record of actual hours.

In developing the analysis, there were a number of factors that received a great deal of attention. They 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.

After a study of these factors was made, it was found that many of them could be measured. The equation used in measuring these factors was discussed and explained in Chapter I.

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.

A certain amount of historical data was necessary for developing the equation and some historical data will be necessary in applying this to future studies; but, if the values of these factors are known, it will speed up the operation considerably, and will make it easier to keep up with technological changes in agriculture.

There are a number of reasons why Burdick's results, as distinct from his method, cannot be applied to central South Dakota. Farming conditions vary considerably even within a state; and therefore, conditions between states are almost certain to be different. There are

differences in climate which will affect the growing season; there will be differences in soil, topography, and size of field which will vary the needs for the type of equipment used; the types of crops grown will vary from one area to the next. The customs of the community will have an effect upon the type of farming enterprise that is established. All of these factors point toward the fact that wherever possible, data that are used in helping farm managers make decisions, should be based on conditions which are similar to the conditions that exist in the area in which they live.

For these reasons, a random sample survey was taken in 1950 to obtain information on typical machines, sequence and number of operations, and rates of performance. 4/ This information was obtained by interviewing individual farmers. The answers to the questions used in the survey were based on farmers' estimates.

In this survey the data gathered on typical machines, and sequence and number of operations were assumed to be accurate; but the information on rates of performance did not appear to be satisfactory. In some cases, the performance of small machines was greater than the larger machines. These inconsistencies can be seen in Table 1.

4/ Oahe Survey, 1950, unpublished data in the Agricultural Economics Department, South Dakota Agricultural Experiment Station.

Table 1. Rates of Performance by Sizes and Types of Implement In Central South Dakota, 1950

Kind	Size	Tractor Horse Power	Number of Cases	Average Acres Per Hour	Average Acres Per Hour Per ft. of Implement
Plow	2-14"	14-20	16	1.01	.44
	2-16"	14-20	13	1.40	.53
	3-14"	14-20	37	1.39	.40
	3-14"	21-29	19	1.29	.37
	3-16"	21-29	7	1.63	.41
	4-14"	21-29	6	1.63	.35
Disc	9'	14-20	6	2.58	.287
	10'	14-20	19	3.52	.352
	12'	14-20	6	3.88	.324
	15'	14-20	13	5.03	.336
Harrow	20'	14-20	14	6.62	.33
	25'	14-20	35	7.81	.31
	30'	14-20	12	13.70	.46

Source: Oahe Survey, 1950, unpublished data in Agricultural Economics Department, South Dakota Agricultural Experiment Station.

For example, for plowing operations, the average acres plowed per hour with a 2-16" plow using a 14-20 horse power tractor was 1.40, compared to an average of 1.29 with a 3-14" plow using 21-29 horse power tractor. For discing operations, the acreage per hour for a 9' disc was half that of a 15' even though the size of tractor used for both sizes of implements was the same. Likewise, for the harrowing operations, the acreage per hour for a 20' harrow was less than one half that of a 30' when the same size tractor was used on both implements.

This inconsistency can be seen more clearly when the acres per hour, per foot-width of implement are compared for the various sizes of implements. When a tractor of a given horse power is used on various sizes of machines, one would expect the acreage per hour, per

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foot-width of implement, to decrease as the size of the implement is increased. This would occur since larger machines would normally decrease the speed of the tractor. The rates of performance as estimated by farmers in the sample, in many cases, show a greater acreage per foot width of implement for the larger machines than for the smaller machines. It is difficult to explain why these inconsistencies should exist. One possible explanation is that it is difficult to estimate rates of performances, especially in cash grain areas where fields are large. Other explanations might be that suitable gear rates were not available where smaller implements were used or that some farmers disliked higher speeds for certain operations.

The information on rates of performance obtained in the 1950 survey was considered unsatisfactory for use in farm planning. As a result, a different approach was used in 1951. The method used in 1951 was discussed in detail in Chapter I.

The data, on rates of performance obtained by these two different methods, differ considerably with respect to variability in hours per acre for a particular operation. The estimates obtained in 1950 indicate a great variation in hours required per acre, while the calculated rates of performances derived from data obtained in the 1951 survey show little differences among farmers in hours required per acre. For example, in Table 2, the standard deviation for the data obtained through estimates is compared to standard deviation for calculated data.

Table 2. Comparison of Variability of Estimated and Calculated Time Requirements for Plowing

Method Used	Number of Cases a/	Mean	Standard Deviation	Mean ± 1 S. D. One S. D.	Two S. D.'s	Three S. D.'s
Estimated	99	.727	.201	.526-.928	.325-1.13	.124-1.330
Calculated	33	.595	.072	.523-.667	.451-.739	.379-.811

a/ Thirty-three cases were not all obtained on the 3-14" plow, but since no association existed between speed and time lost, and size of implement, these data on speed and time lost for the other sizes of plows were applied to the width of 3-14".

Normally, it is not expected that the hours required per acre would vary to any great extent for different farmers in the same area unless there was a great variation in speed.

The data obtained on speed in 1951, with the aid of a stop watch, shows the tractor speed for different operators to be quite uniform. This suggests that the variability of the estimated data, obtained in 1950, is due to errors in estimating rather than in differences in rates of performance.

Since the data on rates of performance, obtained through estimates, appear inaccurate, the rates of performance presented in this study will be calculated, wherever possible, using data obtained in 1951 on speed and time lost.

CHAPTER III

LABOR, POWER, AND MACHINERY RATES OF PERFORMANCE FOR SELECTED DRYLAND OPERATIONS

The purpose of this chapter is to present, in considerable detail, the estimates made regarding labor, power and machinery for selected dryland operations.

In presenting these estimates it will be 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; (3) a presentation of the total requirements per acre for small grains, corn, and hay.

A. Factors Affecting Rates of Performance

There are many factors which influence 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 the rate of speed traveled. 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 speed was probably the most important factor in influencing rates of performance.

Rate of Speed.--According to information obtained in the study of 1951 where field operations were timed, it was found that the 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. Infor-

mation on the Nebraska Tractor Tests shows the speed for the rated load for different makes of tractors varying from three to five miles per hour. 1/ However, for the tractor most common in the area studied, the speed for the rated load is approximately four 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 3.

Time Lost Per Hour.—It was found that for most field operations the time lost per hour was about five minutes. There was some variation here, but it was so small that it was considered insignificant; and therefore, was assumed to be 5 minutes. There were, however, operations in which more time was lost per hour. They were operations such as combining, planting corn, drilling grain, 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.

The time lost per hour for different operations is shown in Table 3.

Sizes and Types of Machines.—Before rates of performance can be

1/ The Nebraska Tractor Tests and Supplement, Nebraska Agricultural Experiment Station Bulletin 397, January 1950.

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 central South Dakota were used. This information was obtained from the random sample survey taken in 1950. 2/

Table 3. Rates of Speed and Time Lost for Operations Timed, by Use of Stop Watch, Central South Dakota, 1951

Operation	Total Cases	Average Rate of Speed	Average Time Lost Per Hour-Minutes 1/
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

1/ 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.

The sizes of the most common tractors and implements on farms in central South Dakota are shown in Table 4.

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"; one-fourth were 2-14"; and all other sizes combined accounted for only one-fourth.

Data were also gathered regarding the size tractor used on tillage

2/ Oahe Survey, 1950, op. cit.

implements of various sizes. This information is presented in Table 5.

The information indicates the power and machinery preference in the central South Dakota area. Conditions of soil and topography influence the power requirements a great deal. In this area tractors ranging from 16-22 drawbar horsepower, which are commonly referred to as 2-plow tractors in the Corn Belt, are used more frequently on 3 bottom plows than are the larger tractors. It was also shown that the smaller tractors were used on the large discs and harrows which usually require larger tractors.

The most common tractor size in this area falls in the 16-22 drawbar horsepower range. This particular size tractor is the most common on all sizes of farms. (See table 6.) 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 discing, harrowing, drilling, swathing, raking and mowing there will be some overlap. This will not be true for row crops; because, due to the nature of the operation, the entire width of the 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 per cent of the actual width of the machine.

Table 4. Percentage Distribution of Tractors and Implements on Sample Farms - Oahe Area (1950). 1/

Kind and Size of Tractor or Implement	Farms Reporting	Kind and Size of Implement	Farms Reporting
	Per cent		Per cent
Tractor DBHP		Corn Planter	
Less than 16	14	2 Row	68
16-22	65	4 Row	28
Over 22	21	Others	4
Total	100	Total	100
Plow		Corn Cultivator	
2-14"	24	2 Row	92
2-16"	16	Others	8
3-14"	49	Total	100
Others	11		
Total	100	Corn Pickers	
		1 Row	73
Disc (single)		2 Row	27
10'	42	Total	100
15'	32		
Others	26	Mower	
Total	100	5'	11
		6'	26
Harrow		7'	63
20'	27	Total	100
25'	40		
30'	21	Swather	
Others	12	12'	60
Total	100	15'	14
		Others	26
Drill		Total	100
10'	27		
11'	35	Combine	
12'	18	5'	29
14'	16	6'	41
Others	4	12'	20
Total	100	Others	10
		Total	100

Source: Oahe Survey, 1950, unpublished data in the Agricultural Economics Department, South Dakota Agricultural Experiment Station.

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

Table 5. Percentage Distribution of Size of Tractor Used on Tillage Implements of Various Sizes on Sample Farms

Type and Size of Implement	Total Cases	Size of Tractor Used: Less than 16 DBHP	16-22 DBHP	Over 22 DBHP	Total
		per cent	per cent	per cent	per cent
Plow					
2-14"	18	6	83	11	100
2-16"	13	23	77	—	100
3-14"	56	2	60	38	100
Disc					
10'	18	—	88	12	100
15'	21	5	57	38	100
Harrow					
20'	17	6	82	12	100
25'	54	6	63	31	100
30'	27	4	37	59	100

Source: Oahe Survey, 1950, unpublished data in the Agricultural Economics Department, South Dakota Agricultural Experiment Station.

Table 6. Percentage Distribution of Number and Size of Tractor 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
	per cent	per cent	per cent
Percentage of farms with one tractor	92	60	6
Percentage of farms with two tractors	8	40	94
Total	100	100	100
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
Total	100	100	100

Source: Oahe Survey, 1950, unpublished data in the Agricultural Economics Department, South Dakota Agricultural Experiment Station.

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 are shown in Table 7.

Table 7. Comparison of Rates of Performance for Different Length Fields

Implement Kind	Implement Size	Length Field in Rods	Speed	Minutes Lost Per Hour	Hours Per Acre 1/
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

1/ 20 seconds allowed for turning on ends. These are calculated rates using Burdick's formula and data from the 1951 survey.

Fuel Consumption Rates.--The estimated fuel consumption was based on the Nebraska Tractor Tests 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 Tractor Tests. To allow for faulty adjustment and normal wear, 10 per cent was added to the Nebraska Tractor Test requirements in calculating these fuel consumption rates.

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

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

Another factor which entered into the calculation of fuel consumption was the load each operation placed upon the tractor. The fuel consumption in the Nebraska Tractor Test was based on full load. Some operations, such as plowing and discing, may place full load upon the tractor used; and others, such as mowing, may place only 10 per cent 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. 3/ His findings are as follows:

	Per Cent of Full Load	Gallons Fuel Per Hour	Fuel as a Per Cent of Full Load
Tandem Disc-Plowing	100	2.85	
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

3/ H. P. Bateman, Effect of Full Load on Farm Machine Operating Economies, Agricultural Engineering, 24: 111-114, April 1943.

The information in this table was used in estimating the fuel consumption presented in Tables 8 and 9. The percentage changes were applied to the full load requirements given in the Nebraska Tractor Tests to determine the fuel requirements for different operations.

B. Calculations of Rates of Performance

Using the information which has been presented above 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 16-22 drawbar horsepower (DBHP). This grouping was used in the calculations shown in Table 8. Another grouping, 23-27 DBHP, was also used to take care of the tractors not included in the first grouping. These calculations are shown in Table 9.

C. Total 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 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 oats, barley, wheat, etc. The calculations made represent requirements for small grain crops under different conditions.

Table 8. Estimated Rate of Performance and Fuel Consumption for Dryland Field Operations With Tractors Ranging From 16-22 in Drawbar Horsepower for Central South Dakota

Implement Kind	Size	Speed	Minutes Lost Per Hour	Tractor Hours Per Acre 1/	Gallons Fuel Per Hour 2/	Gallons Fuel Per Acre
Plow	3-14"	4.0	5	.70	2.1	1.50
Plow	2-16"	4.0	5	1.00	2.0	2.00
Plow	2-14"	4.0	5	1.10	1.9	2.09
Disc (single)	10'	4.0	5	.24	1.7	.41
Disc (single)	12'	4.0	5	.21	1.7	.36
Disc (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 ft. 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

1/ 20 seconds allowed for turning on ends. Length of field - 80 rods.
2/ Fuel requirements based on Nebraska Tractor Tests plus 10% for faulty adjustments and normal wear.

Table 9. Estimated Rate of Performance and Fuel Consumption for Dryland Field Operations With Tractors Ranging From 23-27 in Drawbar Horsepower for Central South Dakota

Implement Kind	Size	Speed	Minutes Lost Per Hour	Tractor Hours Per Acre 1/	Gallons Fuel Per Hour 2/	Gallons Fuel Per Acre
Plow	3-14"	4.0	5	.70	2.5	1.75
Disc (single)	10'	4.0	5	.24	2.2	.53
Disc (single)	12'	4.0	5	.21	2.2	.46
Disc (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

1/ 20 seconds allowed for turning on ends. Length of field - 80 rods.
2/ Fuel requirements based on Nebraska Tractor Tests plus 10% for faulty adjustments and normal wear.

According to data gathered there seemed to be a sizeable amount of both spring and fall plowing in central South Dakota. Thus, calculations were made for small grain on both spring and fall plowing. Also, calculations were made for small grains following corn. It required more labor and fuel to raise small grains on fall plowing than either spring plowing or corn ground. These differences are shown in Tables 10, 11, 12, 15, 16 and 17.

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 13 and 14 for tractors in the 16-22 DBHP range, and Tables 18 and 19 for the tractors in the 23-27 DBHP range.

Haying.--Labor and power requirements were set up for three different methods of haying. These methods are as follows: putting up hay with a one-man pick-up baler; putting up hay with a field chopper with a pick-up attachment; putting up loose hay with a buck stacker. The field chopper was assumed to be run from the power take-off on the tractor.

No information was secured in the 1951 survey on haying operations. The data presented are based on information obtained from studies in other states. The data presented on balers and field choppers are based on information presented in two Nebraska studies and one conducted in Minnesota. 4/ The data presented on putting up loose hay with a buck stacker are based on a time study conducted in Michigan in 1947. 5/

4/ Frank Miller, et al., op. cit.
5/ B. R. Bookhout, Haymaking Job Analysis, Journal of Farm Economics, 29, August 1947.

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

Implements Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
Disc (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 8.

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

Implements Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
Plow	2-16"	1	1.00	2.00	1.05
Disc (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 8.

Table 12. Labor, Fuel Requirements for Small Grain on Spring Plowing in Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implement Kind	Implement Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
Plow	2-16"	1	1.00	1.80	1.00
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			1.88	3.90	2.08

Source: Table 8.

Table 13. Labor, Fuel Requirements for Corn on Spring Plowing in Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implement Kind	Implement Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
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 8.

Table 14. Labor and Fuel Requirements for Corn on Fall Plowing in Central South Dakota (Tractor Size, 16-22 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
Plow	2-16"	1	1.00	2.00	1.05
Disc (single)	12'	1	.21	.36	.22
Harrow	25'	3	.24	.42	.27
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			3.46	5.83	3.70

Source: Table 8.

Table 15. Labor and Fuel Requirements for Small Grain on Fall Plowing in Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
Plow	3-14"	1	.70	1.75	.80
Disc (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 9.

Table 16. Labor and Fuel Requirements for Small Grain on Spring Plowing in Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
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 9.

Table 17. Labor and Fuel Requirements for Small Grain Following Corn in Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
Disc	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 9.

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

Implement Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
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 9.

Table 19. Labor and Fuel Requirements for Corn on Fall Plowing in Central South Dakota (Tractor Size, 23-27 Drawbar Horsepower)

Implement Kind	Size	Times Over	Total Tractor Hrs. Per Acre	Total Gallons Fuel Per Acre	Total Man Hrs. Per Acre
Plow	3-14"	1	.70	1.75	.80
Disc (single)	15'	1	.17	.39	.18
Harrow	30'	3	.21	.42	.24
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			3.09	6.21	3.38

Source: Table 9.

Some data were also taken from a study conducted by the U.S.D.A. published in 1951. 6/ These studies are referred to in the footnotes for Table 20.

It was found that the labor and fuel requirements were highest for baling and lowest for the field chopper, with the requirements for putting up loose hay with the buck stacker being less than the baler and more than the field chopper.

In most cases it will not pay the individual farmer to invest in a field chopper or baler because his hay acreage is not large enough. When this is the case, custom hired machines may be the solution, if machines for hire are available. The availability of the field chopper or baler for custom hire will affect the farmer's choice.

The choice between a baler and a chopper will depend, in part, on the supply of the labor and what the farmer intends to do with the hay. For example, if the hay must be handled a great deal and it is going to be sold, the farmer will probably prefer a baler. The method used may also be influenced by storage facilities, quality of hay and climatic conditions. Finally, it will be influenced by the likes and dislikes of the individual farmer.

The buck stacker requires the smallest investment of the three methods and that is probably one of the big advantages, if the farmer wants to put up loose hay and own his own haying equipment. As mentioned, all three methods have their advantages and disadvantages.

The estimated labor and fuel requirements for moving hay from windrow to storage are shown in Table 20. These calculations are based

6/ R. E. Marx and James A Birkhead, Hay Harvesting Methods and Costs, United States Department of Agriculture Circular 868, June 1951.

on yields in tons of hay per acre, per cutting.

It is assumed that it will take about the same amount of time to mow and rake the hay regardless of yield. However, the speed of travel for the baler, field chopper and buck stacker will be slower with the heavier yield. As the yield decreases, the man hours and tractor hours per acre harvested also decrease; but the man hours and tractor hours per ton of hay harvested increase. The reason for this is that more acres will have to be covered for each ton of hay harvested.

In figuring the difference in man hours per ton and man hours per acre for different yields, it was assumed that for each ton per acre decrease in yield, the man hours per acre were cut by 25 per cent. The tractor hours per acre were assumed to be cut by 10 per cent for each ton per acre decrease in yield. This decrease in tractor labor was smaller than for man labor because the same amount of ground had to be covered even though the yield was less; the only difference here being the increase in speed of travel as yield decreased. The fuel requirements were based on fuel requirements given in Table 8.

Studies have shown that the amount of time required for harvesting hay will vary a great deal, depending upon how the work is organized or planned. The organization of the work is generally agreed to be a more important factor than the kind of machines used. 7/

7/ L. S. Hardin, There is a Best Way for You to Handle Forage, Country Gentleman, July 1952.

Table 20. Estimated Power and Labor Requirements Per Cutting for Moving Hay from Windrow to Storage Using 16-22 Drawbar Horsepower Tractors

Implement	Size Crew	Yield in Tons	Man Hours Per Acre	Man Hours Per Ton	Tractor Hours Per Acre	Tractor Hours Per Ton	Gals. Fuel Per Acre	Gals. Fuel Per Ton
Buck Stacker 1/	3	3	4.5	1.5	1.5	.50	2.3	.8
Baler Pick-up 2/	3	3	5.7	1.9	1.6	.53	4.8	1.6
Field Chopper 2/	3	3	4.0	1.3	1.4	.45	3.5	1.1
Buck Stacker	3	2	3.4	1.7	1.4	.70	2.1	1.0
Baler Pick-up	3	2	4.3	2.1	1.5	.75	4.4	2.2
Field Chopper	3	2	3.0	1.5	1.3	.65	3.3	1.6
Buck Stacker	3	1	2.6	2.6	1.3	1.3	2.0	2.0
Baler Pick-up	3	1	3.2	3.2	1.4	1.4	4.2	4.2
Field Chopper	3	1	2.3	2.3	1.2	1.2	3.0	3.0
Buck Stacker	3	1/2	2.0	4.0	1.2	2.4	1.8	4.8
Baler Pick-up	3	1/2	2.4	4.8	1.3	2.6	3.8	7.8
Field Chopper	3	1/2	1.7	3.4	1.1	2.2	2.8	6.0

1/ Derived from U.S.D.A Circular 868 and Haymaking Job Analysis, Journal of Farm Economics, 29, August 1947.

2/ Derived from U.S.D.A. Technical Bulletin 1037 and Nebraska Agricultural Experiment Station Bulletin 391.

CHAPTER IV

LABOR, POWER AND MACHINERY RATES OF PERFORMANCE FOR SELECTED OPERATIONS UNDER IRRIGATION

The purpose of this chapter is to present information on rates of performance for certain field operations on irrigated land.

Much of the area studied in central South Dakota under dryland conditions is being considered for irrigation. It is important that an attempt be made at estimating some of the rates of performance that would exist under these conditions in the Oahe area. These physical data are presented so that they might be used as a guide in budgeting and planning farm costs for irrigation in the areas in which it has been proposed.

The information presented in this chapter is based on the time study survey made in 1951. Also, information has been taken from other studies made in irrigated areas considered to be similar to that of the Oahe area in soil, climate and rainfall.

A. Factors Bringing About Differences in 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) number of operations necessary for producing comparable crops on dryland and irrigated land are 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.

B. Calculation 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. 1/ Machine sizes were also selected on the basis of standards set up by the Bureau of Reclamation for the Oahe area.

The speed of travel used in calculating rates of performance under irrigated conditions is the same as that used for dryland operations. Implements of comparable size will require less power on dryland than on irrigated land. Therefore, if the same equipment was used 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. Burdick's equation was used in making the calculations. (This equation was explained in Chapter 1.)

The results of the calculations of rates of performance are given in Tables 21, 22, and 23.

1/ Unpublished study on Management Practices and Yields in Lower Yellowstone, North Dakota Agricultural Experiment Station, Agricultural Economics Department, in cooperation with the BAE.

Table 21. Rate of Performance and Fuel Consumption for Operation on Irrigated Land - Field Length 30 Rods

Implement Kind	Size 2/	Speed	Minutes Lost Per Hour	Hours Per Acre 1/	Gallons Fuel Per Hour	Gallons Fuel Per Acre
Plow	2-14"	4.0	5	1.22	1.9	2.32
Disc-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

1/ 40 seconds allowed for turning on ends. Drawbar horsepower of tractor, 16-22.

2/ Rows for sugar beets are 20 inches apart. Potatoes, same as for corn.

Source:

1. The Economics of Sugar Beet Mechanization, Colorado Agricultural Experiment Station Bulletin 411-A, April 1950.
2. Crop Labor Requirements and Seasonal Distribution-Oahe Area, Repayment Unit, Economics and Repayment Section, Bureau of Reclamation, April 1951.
3. Input and Output Data for Principle Crops on Selected Irrigated Soils, Tri-County and Platte Valley Area, Central Nebraska, South Dakota Experiment Station (mimeographed preliminary), April 1951.

Table 22. Rate of Performance and Fuel Consumption for Operation on Irrigated Land - Field Length 21 Rods

Implement Kind	Size 2/	Speed	Minutes Lost Per Hour	Hours Per Acre 1/	Gallons Fuel Per Hour	Gallons Fuel Per Acre
Plow	2-14"	4.0	5	1.40	1.9	2.66
Disc-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

1/ 40 seconds allowed for turning on ends. Drawbar horsepower of tractor, 16-22.

2/ Rows for sugar beets are 20 inches apart. Potatoes, same as for corn.

Source:

1. The Economics of Sugar Beet Mechanization, Colorado Agricultural Experiment Station Bulletin 411-A, April 1950.
2. Crop Labor Requirements and Seasonal Distribution-Oahe Area, Repayment Unit, Economics and Repayment Section, Bureau of Reclamation, April 1951.
3. Input and Output Data for Principle Crops on Selected Irrigated Soils, Tri-County and Platte Valley Area, Central Nebraska, South Dakota Experiment Station (mimeographed preliminary), April 1951.

Table 23. Rate of Performance and Fuel Consumption for Operation on Irrigated Land - Field Length 14 Rods

Implement Kind	Size 2/	Speed	Minutes Lost Per Hour	Hours Per Acre 1/	Gallons Fuel Per Hour	Gallons Fuel Per Acre
Plow	2-14"	4.0	5	1.66	1.9	3.15
Disc-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

1/ 40 seconds allowed for turning on ends. Drawbar horsepower of tractor, 16-22.

2/ Rows for sugar beets are 20 inches apart. Potatoes, same as for corn.

Source:

1. The Economics of Sugar Beet Mechanization, Colorado Agricultural Experiment Station Bulletin 411-A, April 1950.
2. Crop Labor Requirements and Seasonal Distribution-Oahe Area, Repayment Unit, Economics and Repayment Section, Bureau of Reclamation, April 1951.
3. Input and Output Data for Principle Crops on Selected Irrigated Soils, Tri-County and Platte Valley Area, Central Nebraska, South Dakota Experiment Station (mimeographed preliminary), April 1951.

C. Total Requirements Per Acre for Small Grain, Corn, Potatoes and Sugar Beets

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, referred to earlier in the chapter. 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 were 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 in order 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 grown by nearly all farmers in irrigated areas. Therefore, they are an important crop under irrigation.

Operations for raising oats, barley and wheat are all somewhat simi-

lar and therefore, they were all put together under the heading of small grains. Generally, the operations for preparing the land are plowing, discing, 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 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 found in Table 24.

Corn.--Corn is a popular crop in irrigated areas, but not as widely grown as small grains. It would be considered a very important crop 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. Also, we have to include such operations as leveling, ditching and irrigating. In comparing the labor requirements for producing corn on irrigated land and on dryland, we find that it requires almost three times as many man hours on irrigated land as on dryland. The estimated requirements for producing corn under irrigation are found in Table 25.

Sugar Beets.--Sugar beets are one of the most important sources of cash income in irrigated areas.

Plowing is usually the first operation in preparing the land for sugar beets, but sometimes plowing is preceded by discing. Following the

Table 24. Estimated Labor and Fuel Requirements for Small Grain in Areas Selected for Irrigation in Oahe in 1950

Implement Kind	Size	Times Over	Length of field 30 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 21 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 14 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/
Plow	2-14"	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disc-Tandem	8'	1	.44	.86	.46	.49	.98	.51	.51	1.04	.54
Harrow 2/	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 3/		2	—	—	2.60	—	—	2.60	—	—	2.60
Clean Ditches 3/			—	—	.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

1/ Man hours for hauling not included.

2/ Labor and fuel requirements for corrugating, same as that for harrow or cultivator of the same size.

3/ 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.

Table 25. Estimated Labor and Fuel Requirements for Corn in Areas Selected for Irrigation in Oahe in 1950

Implement Kind	Size	Times Over	Length of field 30 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 21 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 14 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/
Plow	2-14"	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disc-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 2/		4	—	—	4.27	—	—	4.27	—	—	4.27
Clean Ditches 2/		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 3/	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

1/ Man hours for hauling not included.
2/ 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.
3/ Spraying for corn borers is figured at the same rate as the third cultivation.

plowing, the land is usually worked down with discs 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.

The harvesting of sugar beets has become 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 the potatoes, and this cuts down the amount of labor necessary. In general, the total labor requirements per acre for potatoes are considerably less than that 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

Table 26. Estimated Labor and Fuel Requirements for Sugar Beets in Areas Selected for Irrigation in Oahe in 1950

Implement Kind	Size	Times Over	Length of field 30 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 21 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 14 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/
Plow	2-14"	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disc-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 2/		1	—	—	5.00	—	—	5.00	—	—	5.00
Ditcher 2/		1	—	—	.47	—	—	.47	—	—	.47
Hoe by hand 2/			—	—	7.35	—	—	7.35	—	—	7.35
Pull top and load 2/		1	3.70	—	4.48	4.00	—	4.98	4.45	—	5.43
Irrigate 3/		5	—	—	7.00	—	—	7.00	—	—	7.00
Total			10.52	12.21	31.45	11.64	13.71	32.84	13.30	15.82	34.54

1/ Man hours for hauling not included.
2/ Labor requirements for thinning, ditching, hoeing, and harvesting were taken from Crop Production Practices in Great Plains, U.S.D.A., BAE, Washington, D. C., 1953.
3/ 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 Areas Selected for Irrigation in Oahe in 1950

Implement Kind	Size	Times Over	Length of field 30 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 21 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/	Length of field 14 rods: Total Tractor Hours Per Acre	Total Gallons Fuel Per Acre	Total Man Hours Per Acre 1/
Plow	2-14"	1	1.22	2.32	1.28	1.40	2.66	1.47	1.66	3.15	1.74
Disc-Tandem	8'	2	.88	1.76	.69	.98	1.96	1.03	1.04	2.08	1.09
Harrow	15'	3	.66	.99	.47	.72	1.08	.78	.84	1.26	.88
Leveler	8'	1	.45	.77	.95	.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 2/		1	—	—	.47	—	—	.47	—	—	.47
Irrigate 3/		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

1/ Man hours for hauling not included.

2/ Labor requirements for ditching were taken from Crop Production Practices in Great Plains, U.S.D.A., BAE, Washington, D. C., 1953.

3/ 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.

CHAPTER V

SUMMARY

The basic problem which brought about this study was the lack of information necessary for determining the most economical use of labor, power and machinery in central South Dakota.

The purpose of this study was to determine labor, power and machinery rates of performance for different farming operations. These rates of performance can be used as a basis for determining costs.

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 one 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. This was done on both dryland and irrigated land. These rates of performance were used in figuring labor, power and fuel requirements for small grain and row crops on a per acre basis.

In reviewing the literature, it was found that studies for determining rates of performance had been made in other states, but there was a lack of information for South Dakota. Different methods were used in making these studies with the interview method, based on farm records and farmers' estimates, being the most frequent. The study made in 1950 in the Oahe area was considered inadequate for determining rates of performance because of the many inconsistencies. The method used in this study is believed to be superior to farmers' estimates

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

such as those secured in the 1950 survey. The inconsistencies that developed, as to rates of performance, in the 1950 study were eliminated.

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 speed 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.

As technological changes take place in agriculture, there will be adjustments necessary in the data presented. Since the data are all presented in physical terms, current prices can be used in evaluating costs.

APPENDIX

TIME REQUIRED FOR FIELD WORK

1. Area ______________________
2. Date ______________________
3. Operator ______________________
4. Address ______________________

South Dakota State College
Agricultural Experiment Station
Project Nos. 198 and 179r-798
Supplement 5
6/27/51

1. Kind of field operation ______________________

2. Tractor: Make __________ Model __________ Year Mfg. __________

3. Operating gear: 1 2 3 4 5

4. Throttled down: Yes ☐ No ☐ Comment ______________________

5. Estimated time required to service tractor:
   Morning ______________
   Noon ______________
   Night ______________
   Total ______________

6. Width of implement ______________________

7. Length of field (rds) __________ Quality of answer __________

8. Length of field as measured by car (mi) ______________________

9. Time required to travel length of field ______________________

10. Time required to turn at each end ______________________

11. Time lost in field during one hour ______________________
    What caused the lost time? ______________________
    ____

12. Are there any peculiarities in regard to soil, topography, shape of field or condition of machine which would cause the time requirement on this field to vary from a normal requirement (comment) ______________________

    ____
    ____
    ____
    ____
    ____
    ____
    ____

13. Interviewed before or after checking ______________________

Signature ______________________

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