A STUDY IN EFFICIENCY OF FARM MACHINERY IN ITS RELATION TO FARM LABOR.

BY

ARTHUR KRATZ WATKINS, B. S. A.

SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN AGR.

in the

GRADUATE SCHOOL

of the

UNIVERSITY OF MISSOURI

Approved
D. H. Doane
May 15, 1912

1912.

INTRODUCTION.

In speaking of Missourians, Joseph E. Wing has said, "They are lovers of broad, fat acres and of animals, good animals - fat Herefords and Shorthorns, good horses, hogs and sheep." And while this is plainly evident at the present time it has not always been so.

Only a few generations ago the farm operations of the Missouri farmer was not carried on on "broad fat acres" but for the most part were confined to a small clearing upon which the work was done by the farmer and his family. The tillable area being small, the farmer's time was not all occupied with farm operations and most all of his labor was directly productive. Food was consumed either upon the farms where it was produced or in the nearby villages. They produced the fiber from which they made their own clothing. Farm buildings usually small and inexpensive were built from materials at hand. In general labor was applied directly to the object in view. If any farmer needed extra help for any particular farm operation he "swopped work" with his neighbors or hired young men or boys from neighboring farms. Tools and machinery were simple and inexpensive; and little or nothing was paid for superintendence. Transportation charges were of little or no importance and there were no middlemen and few profits.

Our modern methods of production in Missouri on "broad fat acres" are vastly different. Many of the products of the farm go to the manufacturer before they come back to the farm for consumption. During the process they must pay many profits besides rent, interest and transportation charges. As civilization advances it seems that our modern methods have a tendency to become more and more complex and indirect.

This has been termed the age of specialists. Trades have developed and segregated themselves until the work once done on the farm by the farmer is now performed by many men in widely separated sections of the world. Within the memory of men still living farmers made their own cradles with which they were obliged to save their wheat and oats; and we have all thought about how much more wheat one can cut with a modern self binder than with the old fashioned cradle. But we are inclined to lose sight of the machine makers, the money lenders, the bankers, the miners, the railroad men, the vast army of office help, the agents and dealers who take part in this same wheat cutting process. True the farmer can do much with the machine after the machinist has finally set it up on his farm but it is an indirect process to get to this point. And each participant in each process expects, and usually receives, his labor wage or profit before the machine is ever put into operation; each of which must be paid by the farmer who generally expects to make it out of his wheat crop. This indirect process is not limited to the wheat crop and binder but the same is true of a large percent of the operations that are carried on on our farms today.

Competition and business interests in the commercial end of all these operations have developed a high productive efficiency; but "statistics show that the average farm laborer produces from two to three times less than the average manufacturing laborer."* If our decreased production per farm worker is due to impaired efficiency and unproductive farm labor, it is time that the farmer on "broad fat acres" should see to it that his idlers go to work and his unproductive workers do more to earn their money. If our pitiably small production per farm laborer is due to the inefficiency and low standards of the teams used, it is "up to" the farmer who would make a profit on "broad fat acres" to use better and more efficient teams in doing his work; for whether the farmer labors efficiently or not he must pay the profits.

Commercial enterprises have employed cooperation to reduce the cost of production and uphold prices but the ~~good old~~ farmer has plodded along, content to do what he could to meet conditions by increasing his yields per acre and broadening his acres. But when he broadens his acreage to any marked degree it usually becomes necessary to employ more help and the employment of much help necessitates closer supervision and, even then, much of the help that is available is not altogether satisfactory.

* J.W.Bennett Arena 37 p.517 May, '07.

In the management of much help on large farms, and more especially on farms owned by men who themselves do not have extensive knowledge of farm work, standards of farm labor would be useful. Many men who are operating farms in Missouri today have very indefinite ideas as to what an average farm hand should do for an average days work. Many farmers know about what their laborers do but they do not know whether their laborers do as much as the average farm worker or not, because there is no available standard by which to compare results.

Of course, conditions under which farm operations must be done vary with different years and in different localities but it must be remembered that the farmer must meet these conditions as they come whether he is able to or not. It is recognized at the outset that no set of rules or standards can be strictly adhered to in the management of a farm, but very serviceable standards may be obtained which would be useful under all conditions. They would enable the farmer to know in advance what provisions to make as to work stock, labor, machinery, etc., and thus save much valuable time at seasons when the loss of a few days might result in serious consequences. The absence of standards whereby farmers may carefully plan their work results in many farmers undertaking more than they can do, while others undertake far less than they should do. Standards of farm work would be of special value at the beginning of a new undertaking. Any farmer who changes from one type of farming to another under the ordinary methods of management which prevail requires two or three years to learn, even approximately, the demands of the new type as to labor and machinery necessary at the different seasons of the year for different crops. He will thus frequently find himself short of labor when most needed and at other times his available labor unoccupied. If the farmer who must change his type of farming could have before him adequate standards of farm labor he could be reasonably sure of how much labor would be required for any given operation and about when his men would be through with that operation and be ready for something else.

The data presented in the following pages is an attempt to establish standards of farm labor from observations of actual practices. It was collected from personal observations by the writer and Mr. L. E. DeVinna of Versailles, Missouri, under the supervision of the U. S. Department of Agriculture, during April, May and June of 1911 on farms in Saline County, Missouri. The farms in this county are practically level and free from stumps and stones. The formulas and the explanations of the same which are hereafter used are practically those furnished by the office of Farm Management in the letter of instruction to field men.

MAN EFFICIENCY.

A very important factor of efficiency is the amount of time the implement is kept in motion during the working day; which has been considered largely dependent upon the workman himself. Whether the percent of the day or hour that the implement is actually kept moving depends more largely upon the workman than the team he is using will be mentioned later in the light of actual figures; but it is an important factor and I will here attempt to show the data necessary to establish, what has been termed, the measure of efficiency of the workman,

Let W equal Width of Machine in feet.
" V " Velocity of machine in miles per hour when actually in motion.
" H " Hours per working day.
" F " Fraction of the day or hour during which machine is actually kept in motion.

Since V is express in miles per hour, to reduce it to feet per hour, we must multiply it by 5280 (the number of feet in a mile). If now we multiply the width of the machine (W) by the velocity in feet per hour (V X 5280) we have the number of feet covered by the machine in one hour. If we divide this by 43560, the number of square feet per acre, we get the acres or fraction thereof that the machine would cover in one hour if it did not stop, $\frac{W(V \times 5280)}{43560}$.

If now we multiply this product by the number of hours (H) in the working day we will have the area that the machine would cover in one whole day if it did not stop. Then if we multiply this product by the fraction of the day (F) during which the machine is actually in motion, we will obtain the actual area (Ad) covered by the machine in one day. Our complete formula then becomes:--

Daily area equals Ad, equals $\frac{W(V \times 5280) \times H \times F}{43560}$;

which reduces to Ad equals .121 WVHF,

or approximately Ad equals $\frac{WVHF}{8}$.

Then to get the value of F. we haveby transposing,

F equals $\frac{8\ Ad}{WVH}$. The value of F will vary with the different types of farm machinery as anyone would not be expected to keep a check row corn planter going as much of the time as he would a drag harrow. In determining the value of F. from this formula, W may be easily determined by measurment of the machine. V. can be determined by observing how long it takes to go a given distance. H. is the number of hours in the working day and may be easily ascertained in any given case. Ad. is the total area actually covered in a day and may be easily determined by measurment. When we have these factors the value of F. can be readily calculated. When the value of F. has been determined for a given implement we can compare the efficiency of that implement with that of any other field implement for which a similar value has been obtained.

To illustrate the working of the formula and the use of F. let us compare the efficiency of two men, one of whom is operating a gang plow and the other a checkrow corn planter. In the case of the gang plow we will have: W equals 2 ft.; and from table No. XII we find V equals 2.56; H equals 10 hours per day; and Ad equals 4.71 acres. Thus we have

$$F \text{ equals } \frac{8\ Ad}{WVH} \text{ equals } \frac{8 \times 4.71}{2 \times 2.56 \times 10} \text{ equals } .74.$$

Which means that the gang plow is actually kept moving 74 percent of the time. In the case of the corn planter we find (Table No. XII) W. equals 7 ft.; V. equals 2.49 miles per hour; H. equals 10 hours per day; and Ad. equals 14.37 acres per day. Hence we have

$$F \text{ equals } \frac{8 \times 14.37}{7 \times 2.49 \times 10} \text{ equals } .66.$$

Thus in the two cases compared we may say that the average man who operates a gang plow keeps it moving 74 percent of the time while the average man who operates a checkrow corn planter keeps it in motion only 66 percent of the time.

DAILY DUTY OF FIELD MACHINERY.

By the duty of field machinery is here meant the amount of work a machine may be expected to do or the area it will cover in one day.

The original formula on page 5 may be written as follows:

$$Ad \text{ equals } WH \left(\frac{V \times 5280 \times F}{43560}\right).$$

Since F. is the fraction

of time the machine is kept in motion, it may be the fraction either of an hour or of the whole day. Considering the quantity in parenthesis in the above formula: We find the numerator is the hourly velocity of the machine expressed in feet, multiplied by the fraction of the hour during which the machine is actually in motion. The whole numerator, therefore, gives the actual distance the machine moves in an hour, on the average. If we consider one foot in width of the machine, this numerator would then represent the area in square feet actually covered by one foot in width of the machine in one hour. Then if we divide this numerator by 43560, the number of square feet in an acre, we will get, from the quantity in parenthesis, the fraction of an acre actually covered by one foot in width of the machine in one hour, under average conditions. Now if we substitute E (the initial letter of the word efficiency) for the parenthesis, our formula will be Ad equals WHE for the daily efficiency of the machine. W. is the width of the machine expressed in feet, Ad. is the area actually covered by the machine in a day. H. is the number of hours per working day and E. is the fraction of an acre actually covered by one foot in width of the machine in one hour, on the average. Ad., W. and H. are easily determined and when we have these factors we can readily calculate the value of E which we will call the hour-foot efficiency of the machine. When we have the value of E for any given machine we can compare the efficiency of that machine with that of any other machine for which a similar value has been determined, regardless of the type of implement or the width of the machines.

RECAPITULATION.

For convenience of reference the various formulae and symbols used im this paper are here brought together.

W.	equals	width of machine, in feet.
V.	"	velocity of machine in miles per hour.
H.	"	hours per working day.
F.	"	fraction of the day (or hour) the machine is actually kept in motion.
Ad.	"	acres per day or area covered in one day.
D.	"	days in period during which work must be done.
P.	"	proportion of those days actually available for work, on the average.
C.	"	proportion of time devoted to a given operation, as opposed to other concurrent operations.
T.	"	times the land is gone over.
As.	"	acres per season - area covered in period D.
E.	"	hour-foot efficiency of machine - the fraction of an acre in area covered in one hour for each foot in width of the machine.

Man efficiency: F equals $\frac{8\ Ad}{WVH}$

Daily duty of machinery: Ad " W.H E acres

Seasonal duty of machinery: As " $\frac{EWHDPC}{T}$ acres.

Hour-foot efficiency of machine: E " $\frac{VX5280XF}{43560}$ acres.

The following tables I to XI inclusive, are simply records of personal observations and include all observations, as far as is known, that have been recorded on farm operations in Missouri. It must always be borne in mind that the number of observations here recorded is not sufficiently large to say that the conclusions drawn from them are absolutely correct and conclusive. And while they are not offered here to show the extent of any tendency they certainly may be taken as showing the direction of that tendency.

TABLE NO. I.

DISCING.

No. Men	H.	Depth Worked	Horses No.	Horses Wt.	Width Worked	Length of row	V.	Ad.	F.	E.
1	10.	4.0 in	4	1300	7.0 ft.	80. rd.	2.72	17.5	.73	.240
1	10.	2.0 "	4	1100	7.0 "	43. "	2.5	13.0	.59	.179
3	11.	3.0 "	12	1100	3.5 "	40. "	2.0	8.8	.91	.22
1	10.	3.0 "	4*	1100	7.0 "	80. "	2.5	18.3	.83	.252
1	10.	3.0 "	4*	1200	3.0 "	80. "	3.0	7.63	.68	.246
1	10.	4.0 "	4	1000	6.0 "	80. "	2.0	12.00	.60	.182
1	8.5	4.0 "	4*	1100	7.0 "	80. "	2.5	17.6	.95	.287
1	10.	3.0 "	4*	1075	3.5 "	82. "	2.5	10.0	.91	.276
1	10.	3.0 "	4	1000	8.0 "	69. "	2.5	17.0	.63	.191
1	10.	3.0 "	4	1050	7.0 "	42. "	3.0	18.4	.70	.252
1	11.	3.0 "	4	1100	7.5 "	80. "	2.5	21.6	.84	.256
1	10.	3.0 "	4	1200	3.5 "	42.4 "	3.0	10.65	.81	.294
1	10.	3.0 "	4	1200	3.5 "	42. "	2.5	8.0	.73	.220
1	10.	2.0 "	4	1100	7.0 "	66. "	2.5	12.0	.55	.166
1	10.	2.0 "	4	1300	7.0 "	50. "	2.7	15.6	.66	.216
1	10.	2.0 "	4	1000	7.0 "	70. "	2.6	17.0	.90	.283
1	11.	3.0 "	4	1100	3.5 "	80. "	2.5	6.7	.56	.170
1	10.	3.0 "	4	1000	8.0 "	70. "	2.0	15.2	.76	.223
1	10.	3.0 "	4*	1050	8.0 "	80. "	2.5	13.3	.53	.160
2	10.	3.0 "	8*	1100	3.5 "	80. "	3.5	9.38	.86	.260
2	11.	3.0 "	8*	1200	3.5 "	160. "	3.0	11.6	.85	.308
1	9.	3.0 "	4*	1100	7. "	85. "	2.	8.18	.52	.186
1	10.	3.0 "	4	1000	6.5 "	80. "	2.0	15.	.92	.223

* Mules.

TABLE NO. II.

BREAKING FOR CORN.

	No. Men	H.	Depth Worked	Horses No.	Horses Wt.	Width Worked	Length of Row	V.	Ad.	F.	E.
G	2	10.	6. in.	8*	1150.	2. ft.	80. rds.	3.00	4.38	.585	.212
G	1	10.	6. "	4	1300.	2. "	80. "	2.5 ♣	4.38	.702	.215
	1	10.	6. "	3*	1300.	1.33 "	74. "	3.4 ♣	3.56	.630	.260
G	1	10.	5. "	4	1300.	2. "	140.5 "	3.0	6.62	.890	.323
G	1	11.	6. "	4*	1150.	2. "	72. "	3.0	5.96	.72	.262
G	1	10.	5. "	4*	1200.	2. "	80. "	3.0	5.75	.77	.27
G	1	10.	5. "	4	1200.	2. "	88.5 "	2.7	6.00	.89	.29
G	1	11.	6. "	4	1100.	2. "	126. "	2.14♣	5.07	.86	.184
	1	11.	8. "	3	1000.	1.16 "	80. "	2.5	3.3	.83	.251
S	1	10.	6. "	3	1050.	1.16 "	47. "	2.0	2.67	.92	.223
S	1	10.	6. "	3*	1250.	1.33 "	80. "	3.0	3.25	.65	.236
G	2	10.	5. "	8*	1300.	2. "	70. "	3.0	4.89	.65	.236
G	2	9.	6. "	8*	1150.	2. "	80. "	2.0	2.36	.52	.126
	2	10.	7. "	6*	1050.	1.33 "	54. "	2.5	2.6	.63	.190
	1	10.	6. "	2	1000.	1.16 "	80. "	2.5	2.02	.58	.176
	2	10.	8. "	6*	1100.	1.33 "	114. "	2.5	3.11	.80	.242
G	1	10.	6. "	4	1200.	2. "	40. "	2.0	3.5	.70	.169
S	1	10.	7. "	3	1000.	1.33 "	78. "	2.0	2.5	.75	.182
G	2	10.	7. "	8*	1100.	2. "	80. "	2.5	4.67	.74	.242
S	1	10.	7. "	3*	1050.	1.33 "	40. "	2.5	3.25	.78	.236
S	1	10.	6. "	3	1100.	1.33 "	80. "	2.5	3.65	.84	.264
S	1	10.	7. "	3*	1100.	1.33 "	80. "	2.5	4.0	.96	.290
	1	10.	8. "	3*	1100.	1.33 "	80. "	3.0	3.37	.68	.247
S	1	10.	8. "	4*	1150.	1.16 "	80. "	3.0	4.2	.97	.352
G	1	11.	7. "	4*	1250.	2.0 "	52.7 "	3.0	6.6	.80	.291
	2	10.	6. "	6	1350.	1.33 "	39.5 "	2.0	2.2	.66	.160
	3	10.	7. "	6	1100.	1.16 "	80. "	2.5	2.33	.64	.194
S	2	10.	6. "	6	1100.	1.16 "	82. "	2.0	1.78	.61	.148
	1.	10.	6. "	3	1100.	1.16 "	80. "	2.5	3.0	.83	.251
G	1	11.	6. "	4*	1150.	2. "	120.5 "	2.0	4.1	.75	.182
	1	10.	7. "	3*	1200.	1.33 "	55. "	2.5	3.08	.74	.244
	1	10.	6. "	3	1200.	1.33 "	39. "	2.0	2.0	.60	.145
	1	11.	6. "	3*	1150.	1.33 "	69. "	3.0♣	3.95	.72	.262
	1	11.	4. "	3	1100.	1.33 "	80. "	2.5	2.8	.61	.185
G	1	10.	6. "	4	1250.	2. "	67. "	2.51	5.0	.80	.243
G	2	10.	6. "	8*	1200.	2. "	82. "	2.19	5.0	.91	.241
G	1	10.	6. "	4	1100.	1.66 "	80. "	2.5	4.0	.77	.294
G	1	10.	6. "	4*	1200.	2. "	80. "	2.5	5.6	.89	.269
	2	10.	6. "	6*	1000.	1.33 "	140. "	2.39♣	3.0	.76	.220
	1	10.	6. "	2	1000.	1. "	67. "	1.8	1.3	.58	.126

* Mules
♣ Clover Sod (Stalk or stubble, except where noted).
G Gang Plows
S Sulky Plows

TABLE NO. III.

SMOOTHING HARROW.

No. Men	H.	Horses No.	Horses Wt.	Width Worked	Length of Row	V.	Ad.	F.	E.
1	11.	4*	1100	12 ft.	80. rd.	2.5	33.	.79	.300
1	10.	4*	1200	10 ft.	80. "	2.5	25.	.80	.193
1	10.	4*	1050	10. "	80. "	2.5	19.6	.63	.191
1	10.	4	1150	10. "	80. "	2.25	16.7	.59	.161
1	10.	2*	950	7.5 "	80. "	2.31	16.8	.83	.232
1	11.5	3	1150	10. "	80. "	2.5	23.	.64	.194
1	10.	2	1050	8. "	43.3"	2.31	21.5	.95	.265
1	10.	4*	950	15. "	145. "	1.82	23.3	.68	.150
1	11.	3	1200	10. "	76.5"	2.21	25.5	.83	.222
1	11.	2	1200	8. "	81. "	2.53	27.1	.98	.301
2	10.	4*	1100	9. "	80."	1.87	9.43	.45	.102
1	10.	2	1200	10.5 "	78. "	1.95	13.5	.53	.125
1	10.	2*	1100	7. "	80. "	2.5	17.6	.80	.242
2	10.	4*	1150	7.3 "	120. "	2.35	11.9	.55	.157
1	10.5	2	1200	7.3 "	61.8"	2.9	17.1	.62	.217
1	10.	4*	1000	6. "	61. "	2.5	16.	.85	.256
1	10.	3	1050	10. "	42.1"	2.5	19.	.61	.165
1	10,	4*	1150	10. "	80. "	2.5	27.1	.86	.260
1	10.	2*	1150	7. "	80. "	3.0	25.5	.97	.350
1	10.	4	1000	10. "	80. "	2.5	25.0	.80	.242
1	10.	4*	1100	10. "	80. "	3.0	22.2	.59	.214
1	10.	4	1000	12. "	80. "	2.5	30.3	.80	.214
1	10.	3*	1200	7. "	36. "	2.5	14.3	.65	.197
1	10.	4*	1100	8. "	80. "	2.5	11.66	.47	.142
1	10.	4*	1000	10. "	80. "	3.0	20.0	.66	.238
1	11.	3	1100	10. "	54. "	2.7	14.7	.40	.131
1	11.	4*	1000	8. "	80. "	2.5	17.6	.64	.193
1	10.	3*	1100	6. "	80. "	2.73	14.0	.74	.244
1	11.	5	1100	8. "	120. "	2.5	22.4	.81	.244
1	10.	4*	1050	10. "	120. "	2.25	15.3	.54	.147
1	11.	4	1100	10. "	65. "	2.0	23.15	.84	.204
1	10.	4	1100	5.5 "	42. "	2.0	11.4	.83	.201
1	10.	3	1075	11. "	120. "	2.0	20.8	.75	.182
1	10,	2*	1050	9. "	127. "	2.16	22.5	.92	.241
1	11.	2*	1125	10. "	80. "	1.87	14.6	.52	.117
1	10.	3*	1000	8.75"	78. "	2.43	22.2	.83	.242
3	10.	9	1050	10.5 "	78. "	2.44	12.3	.38	.112
1	10.	3	1150	10.5 "	95. "	2.7	17.4	.49	.160

TABLE NO. IV.
PLANTING CORN.

	No. Men	H.	Depth Worked	Team No.	Team Wt.	Rows Width	Rows Length	V.	Ad.	F.	E.
	1	10.	4. in.	2*	1100	7. ft.	80. Rd.	2.5	15.6	.71	.251
#	1	10.	5. "	2*	1150	7.3 "	160. "	2.5	16.0	.70	.211
#	1	11.	4. "	2	1050	7. "	160. "	2.0	17.0	.88	.212
#	1	10.	6. "	2*	1000	7.3 "	120. "	2.0	16.0	.90	.218
#	1	11.	6. "	2*	1175	7. "	30. "	3.0	11.9	.41	.149
#	1	10.	6. "	2	1250	7. "	80. "	3.0	12.0	.46	.167
	1	10.	6. "	2	1050	7. "	80. "	3.0	14.8	.56	.203
	1	11.	6. "	4*	1100	7. "	160. "	3.0	22.0	.76	.276
#	1	11.	5. "	2	1300	7.3 "	58.5 "	2.19	20.3	.92	.244
#	1	10.	5. "	2*	1150	7.3 "	25.4 "	1.59	8.27	.57	.110
#	1	10.	5. "	2*	1100	7. "	80. "	2.72	14.15	.59	.201
#	1	10.	2. "	2*	1200	7. "	80. "	2.0	10.0	.61	.148
#	1	10.	5. "	2*	1100	6.6 "	80. "	2.5	16.0	.77	.234
#	1	10.	5. "	2*	1000	7. "	70. "	2.5	16.0	.73	.221
#	1	8.5	4. "	2*	1100	7. "	80. "	2.5	14.05	.75	.212
#	1	10.	5. "	2*	1250	7. "	35. "	2.25	12.3	.62	.169
#	1	10.	5. "	2*	1250	7. "	120. "	2.25	10.6	.54	.147
#	1	11.	2. "	2	1000	7. "	30. "	2.0	11.5	.60	.145
#	1	10.5	2. "	2	1200	7.3 "	80. "	2.5	17.8	.74	.185
#	1	11.	2. "	2*	1150	7.3 "	40. "	3.0	20.9	.69	.251
#	1	10.	2. "	2	1100	7.3 "	40. "	2.5	12.74	.56	.170
#	1	10.	2. "	2*	1200	7. "	80. "	2.14	10.9	.58	.150
#	1	10.	2. "	2	1100	7. "	80. "	2.5	14.0	.64	.194
#	1	10.	2. "	2*	900	7.3 "	61.5 "	2.0	15.0	.82	.198
#	1	11.	2. "	2	1300	7.3 "	80. "	2.5	21.1	.84	.254
#	1	11.	2. "	2*	1200	7. "	80. "	3.0	24.2	.83	.302
#	1	10.	3. "	2*	1000	7. "	80. "	2.0	12.83	.73	.177
#	1	10.	5. "	2*	1150	7.3 "	60. "	2.0	9.73	.53	.128
	1	11.	3. "	2	1000	7. "	80. "	2.0	10.34	.54	.131
#	1	10.	2. "	2	1200	7.3 "	76. "	2.5	17.0	.75	.228
#	1	10.	3. "	2	1100	7. "	37.5 "	2.0	6.67	.38	.092
#	1	10.	3. "	2*	1250	7. "	45. "	3.0	26.0	.99	.360
#	1	10.	3. "	2	1000	7. "	80. "	3.0	11.35	.43	.156
#	1	11.	3. "	2	1250	7. "	80. "	3.0	16.1	.50	.182
#	1	10.	3. "	2*	1200	7. "	80. "	3.0	20.0	.95	.345
	1	10.	4. "	4	1150	7.3 "	95. "	2.7	17.4	.70	.229
#	1	10.	2. "	2	1000	7.3 "	80. "	2.0	12.55	.69	.167
	1	10.	3. "	2	1050	7. "	66. "	1.75	8.16	.53	.112
#	1	10.	2. "	2*	1400	7. "	80. "	3.0	18.2	.69	.250
#	1	10.	2. "	2*	1200	7. "	90. "	1.88	15.1	.91	.270
#	1	10.	3. "	2	1000	7. "	53.3 "	3.28	14.7	.51	.202
#	1	11.	2. "	2*	1200	6.6 "	62. "	2.7	9.9	.40	.131
#	1	10.	2. "	2	1100	7. "	43. "	3.0	11.8	.45	.164
#	1	10.	2. "	2	1200	7. "	60. "	3.0	15.1	.58	.210
	1	10.	2. "	2	1200	7. "	80. "	2.0	13.6	.78	.189
	1	11.	2. "	2*	1150	6.6 "	160. "	3.3	20.2	.71	.283
#	1	10.	2. "	2	1100	7. "	75. "	2.5	14.0	.64	.193
#	1	10.	2. "	2*	1200	7.3 "	104. "	2.5	12.7	.56	.170
#	1	10.	2. "	2	1000	7. "	65. "	2.5	11.7	.53	.160
#	1	10.	2. "	2	1200	7. "	100. "	2.25	12.6	.64	.174
	1	10.	2. "	2	1100	7. "	80. "	2.5	16.0	.73	.221
#	1	10.	2. "	2	1050	7. "	118. "	3.0	18.5	.71	.258
	1	10.	2. "	2*	1100	7. "	70. "	2.5	17.6	.76	.230
	1	11.	2. "	2*	1200	7. "	80. "	3.0	17.6	.61	.231
	1	9.	2. "	2	1100	7. "	95. "	2.0	13.7	.87	.211

*Mules. # Check Row Planter.

TABLE NO. V.

ROLLING CORN.

No. Men	H.	Horses		Width Worked	Length of Row	V.	Ad.	F.	E.
		No.	Av.Wt.						
1	10.	2.	1300.	7. ft.	80.Rd.	3.33	21.6	.73	.295
1	10.	2	1200.	8. "	80. "	2.31	19.01	.82	.230
1	10.	2	1000.	8. "	53.7 "	2.52	18.9	.75	.230
1	11.	2	1100.	8. "	80. "	3.0	25.0	.75	.272
1	10.	2	1150.	7. "	78. "	2.66	13.8	.60	.193
1	11.	2	1050.	7. "	76. "	2.19	12.2	.58	.154
1	10.	2	1100.	8. "	79. "	2.68	15.7	.59	.191
1	11.	3	1100.	8. "	80. "	2.14	20.0	.88	.228
1	10.	2*	1200.	8. "	83.2 "	3.12	29.5	.94	.355
1	10.	2*	1150.	8. "	145. "	2.1	11.8	.51	.130
1	10.	2#	1500.	7. "	80. "	3.52	29.1	.94	.400
1	10.	2*	1250.	7. "	79. "	2.96	24.7	.95	.340
1	10.	2	1300.	7. "	159. "	2.71	23.0	.97	.318
1	10.	2	1100.	7. "	79. "	1.97	16.8	.97	.231
1	10.	2*	1150.	7. "	120. "	3.08	24.5	.91	.280
1	10.	4	1200.	7. "	80. "	2.44	14.3	.65	.196
1	11.	2	1100.	6. "	120. "	2.5	19.9	.96	.290
1	10.	2	1000.	8. "	80. "	2.64	21.3	.81	.214
2	10.	4	1100.	9. "	80. "	1.87	9.43	.45	.102

* Mule teams.

This was a team of grade percherons.

TABLE NO. VI.

PLOWING CORN; - FIRST CULTIVATION.

No. Men	H.	Depth Worked	Horses No.	Horses Wt.	Rows Width	Rows Length	V.	Ad.	F.	E.
1	11.	3. in.	3	1000	6.6 ft.	80. rd.	1.87	12.8	.75	.170
3	10.	5. "	6	1100	3.5 "	80. "	2.15	5.6	.59	.157
3	10.	6. "	6*	1100	3.6 "	80. "	2.5	6.6	.59	.183
2	10.	5. "	4*	1000	3.5 "	120. "	2.02	7.5	.85	.213
2	11.	3. "	4*	1150	3.5 "	138.5 "	1.92	8.9	.97	.231
1	10.	4. "	2*	1100	3.5 "	405. "	1.51	6.2	.94	.170
1	11.	5. "	2*	1200	3.5 "	104. "	2.43	11.0	.94	.270
1	10.	5. "	2*	1100	3.6 "	80. "	2.31	10.4	.97	.280
1	11.	5. "	3*	1200	7.0 "	204. "	2.16	14.4	.69	.185
1	10.	5. "	2*	1100	3.6 "	75. "	2.0	8.15	.90	.223
2	11.	4. "	4*	1000	3.6 "	80. "	1.87	6.75	.73	.170
2	10.	5. "	4	1200	3.6 "	54.7 "	1.55	6.05	.97	.187
2	10.	5. "	4*	1000	3.6 "	80. "	2.31	7.25	.58	.166
2	10.	5. "	4	1175	3.5 "	84. "	1.56	5.7	.83	.160
2	10.	3. "	4*	1100	3.5 "	44.3 "	1.8	7.3	.81	.180
3	10.	5. "	6*	1200	3.5 "	71.5 "	1.78	5.75	.72	.160
1	11.	2. "	2#	1350	3.5 "	80. "	3.5	8.77	.97	.220
3	11.	4. "	6*	1100	3.6 "	120. "	3.0	13.5	.91	.338
1	10.	4. "	2	1100	3.5 "	85. "	2.24	6.45	.66	.183
2	10.	4. "	4*	1050	3.5 "	160. "	2.4	10.2	.97	.270
2	10.	4. "	4	1100	3.5 "	60. "	1.73	5.22	.69	.148
3	10.	5. "	6*	1100	3.5 "	140. "	2.4	4.95	.55	.164
2	9.	5. "	4	1250	3.6 "	61.5 "	1.15	4.6	.99	.138
1	10.	5. "	2*	1050	3.5 "	80. "	2.0	8.32	.95	.230
3	11.	5. "	6*	1000	3.5 "	129. "	1.73	6.03	.73	.156
1	10.	5. "	2	1250	3.6 "	39. "	1.57	5.4	.76	.147
1	10.	3. "	2*	1100	3.5 "	80. "	2.3	9.43	.93	.266
1	10.	5. "	2	1150	3.6 "	80. "	2.0	8.94	.99	.246
2	10.	3. "	4*	1150	3.5 "	80. "	2.5	7.56	.69	.214
2	10.	4. "	6*	1150	7.0 "	160. "	2.14	14.02	.75	.194
2	11.	5. "	4*	1050	3.5 "	80. "	1.87	8.75	.97	.220
1	10.	4. "	2	1050	3.6 "	43.3 "	1.47	6.1	.92	.168
2	10.	3. "	4	1100	3.5 "	55.5 "	2.31	6.56	.64	.184
2	10.	4. "	4	1100	3.5 "	80. "	2.5	9.3	.85	.264
3	10.	4. "	6	1100	3.5 "	120. "	1.8	4.74	.60	.134
1	10.	4. "	2#	1300	3.5 "	80. "	2.0	8.52	.97	.236
1	10.	4. "	2	1200	3.5 "	68. "	2.55	7.22	.65	.205
1	10.	4. "	2	1300	3.6 "	80. "	1.87	7.5	.90	.209
1	10.	4. "	2*	1200	3.5 "	65. "	2.02	8.6	.97	.244
2	11.	4. "	4	1100	3.33"	75. "	2.01	5.8	.69	.170
1	11.	3. "	2	1150	3.5 "	60. "	1.5	6.1	.93	.168
2	11.	4. "	4	1000	3.5 "	76. "	2.03	8.33	.85	.214
2	11.	4. "	4	1050	3.5 "	61. "	1.43	4.96	.72	.128
1	11.	4. "	2*	1150	3.3 "	80. "	2.5	8.8	.78	.242
2	10.	4. "	4	1150	3.5 "	99. "	1.69	6.62	.89	.187
1	10.	3. "	2	1200	3.5 "	80. "	1.67	6.73	.92	.190
1	10.	5. "	2*	1000	3.5 "	40.6 "	1.9	8.08	.97	.223
2	11.	4. "	4*	1200.	3.6 "	55. "	1.72	7.67	.90	.192
1	10.	4. "	2*	1000	3.5 "	23. "	2.16	6.25	.66	.172
2	10.	4. "	4*	1000	3.5 "	80. "	2.0	6.28	.72	.174

* Mule teams.
# Grade percherons.

TABLE NO. VII.

PLOWING CORN; - SECOND CULTIVATION.

No. Men	H.	Depth Worked	Horses No.	Horses Av.Wt.	Rows Width	Rows Length	V.	Ad.	F.	E.
3	11.	5.in.	6	1250	3.5ft.	100.rd.	2.03	6.82	.70	.172
3	10.	5. "	6*	1200	3.5 "	80. "	2.5	9.02	.82	.248
2	10.	5. "	4#	1400	3.5 "	80. "	2.14	7.35	.78	.202
1	11.	4. "	2*	1150	3.6 "	86. "	2.0	7.63	.77	.185
3	10.	3. "	6*	1200	3.5 "	103. "	1.92	6.6	.77	.178
1	10.	4. "	2*	1000	3.6 "	79.5"	1.86	6.23	.74	.166
1	11.	6. "	2	1000	3.5 "	55.7 "	2.32	9.05	.81	.228
2	11.	3. "	4	1100	3.5 "	76. "	2.57	8.43	.68	.210
3	11.	4. "	6	1100	3.5 "	80. "	2.5	5.75	.48	.145
2	8.	4. "	4	1200	3.5 "	33. "	1.65	3.58	.62	.124
1	10.	5. "	2#	1375	3.5 "	80. "	2.4	9.9	.94	.264
1	10.	3. "	3*	1100	7.0 "	120. "	2.0	16.3	.93	.225
1	10.	5. "	2*	1050	3.5 "	75. "	2.81	10.5	.63	.177
1	10.	4. "	2	1200	3.5 "	80. "	2.5	6.06	.55	.166
2	10.	4. "	4*	1275	3.5 "	155. "	1.62	4.75	,65	.127
1	10.	4. "	2*	1100	3.5 "	80. "	1.87	5.2	.64	.145
2	10.	4. "	4	1100	3.5 "	49.3"	2.32	5.24	.52	.146
1	9.	4. "	2	1200	3.6 "	40. "	2.3	6.0	.63	.175
1	10.	4. "	3*	1100	7.0 "	120. "	2.66	11.4	.49	.163
1	10.	4. "	2*	1000	3.5 "	80. "	3.0	16.0	.96	.350
3	9.5	3.5"	6*	1150	3.6 "	75. "	2.56	6.25	.57	.177
2	10.	3. "	4	1300	3.5 "	140. "	2.72	7.9	.66	.217
1	11.	3. "	2	1200	3.6 "	80. "	2.72	9.98	.74	.244
1	10.	3.5 "	2	1250	3.6 "	35. "	2.04	8.1	.88	.217
2	10.	5. "	4	1000	3.6 "	54. "	2.24	7.75	.77	.208
3	10.	4.5"	6	1150	3.6 "	80. "	1.25	4.82	.86	.130
1	11.	4. "	3*	1250	7.0 "	153. "	2.39	22.4	.97	.281
1	10.	5. "	3*	1200	7.0 "	80. "	2.0	16.1	.92	.222
1	10.	4. "	2	1200	3.5 "	57. "	1.53	5.58	.83	.154
1	10.5	4. "	2*	1300	3.5 "	80. "	2.14	8.9	.90	.232
2	10.	4. "	4*	1000	3.5 "	45. "	1.69	5.23	.71	.145
2	10.	4. "	4*	1300	3.5 "	80. "	2.4	4.78	.46	.134
2	10.	4. "	4	1200	3.5 "	44. "	1.67	5.46	.75	.150
2	11.	3. "	4	1100	3.3 "	120. "	1.57	7.0	.98	.186
1	10.5	4. "	2	1100	3.5 "	80. "	1.66	6.8	.89	.180
1	10.	3.5"	2*	1150	3.5 "	80. "	1.87	7.22	.94	.213
1	11.	3. "	3*	1200	7.0 "	160. "	2.22	18.8	.87	.234
1	10.	4. "	2*	950	3.5 "	80. "	1.67	6.3	.86	.174
1	11.	4. "	3*	1200	7.0 "	80. "	2.0	17.3	.90	.218

* Mule teams.
# Grade percheron teams.

TABLE NO. VIII.

PLOWING CORN; - THIRD CULTIVATION.

No. Men	H.	Depth Worked	Horses		Rows		V.	Ad.	F.	E
			No.	Av.Wt.	Width	Length				
1	11.	3. In.	3*	1300	7.0 ft.	80. rd.	3.0	24.3	.84	.312
1	10.	3.0 "	2*	1000	3.5 "	80. "	2.5	10.06	.97	.294
2	10.	5.0 "	4*	1000	3.5 "	36. "	1.48	5.17	.78	.143
1	10.	4.0 "	2*	1000	3.5 "	80. "	2.5	8.48	.77	.248
1	10.	4.0 "	2*	1050	3.5 "	65. "	2.8	6.5	.53	.184
1	10.	3.0 "	2*	1100.	3.5 "	80. "	2.5	6.68	.60	.186
2	10.	4.0 "	4*	1100	3.5 "	80. "	2.5	9.2	.65	.199
1	11.	4.0 "	2*	1075	3.5 "	52.8"	2.45	9.55	.81	.240
1	11.	3.5 "	2*	1150	3.5 "	80. "	3.0	8.98	.62	.225
1	11.	5.5 "	3*	1100	7.0 "	80. "	3.0	26.7	.96	.348
2	10.	3.5 "	4*	1150	3.5 "	80. "	2.5	7.43	.67	.203
1	10.	3.0 "	2*	1100	3.6 "	80. "	2.61	9.7	.83	.262
1	9.	2.5 "	2	1200	3.5 "	80. "	2.72	9.78	.91	.300
3	10.	3.5 "	6*	1100	3.6 "	80. "	2.72	10.0	.84	.276
1	10.	3.5 "	2	1100	3.6 "	73. "	2.1	7.88	.83	.210
2	10.	3.0 "	4	1150	3.6 "	58.8"	1.88	6.53	.77	.175
1	11.	3.0 "	2	1150	3.5 "	80. "	1.88	7.95	.88	.200
2	10.	4.0 "	4*	1250	3.6 "	50. "	1.87	5.5	.65	.147
1	10.	3.5 "	2	1300	3.6 "	80. "	2.0	6.67	.74	.180
2	11.	4.0 "	8*	1200	7.0 "	160. "	2.6	16.8	.67	.210
2	10.	4.0 "	4	1200	3.5 "	60. "	2.5	7.95	.73	.233
1	10.	4.0 "	2	1200	3.5 "	80. "	2.14	7.43	.80	.207
1	10.	3.0 "	2*	1250	3.5 "	88. "	2.54	10.3	.93	.286
2	11.	4.0 "	4*	1100	3.5 "	160. "	2.3	10.5	.95	.264
1	10.	4.0 "	2*	1200	3.5 "	40. "	1.87	7.43	.89	.202
3	10.	4.0 "	6*	1200	3.5 "	160. "	2.6	8.3	.73	.233

*Mule teams.

TABLE NO. IX.

PLOWING CORN; - FOURTH CULTIVATION.

No. Men	H.	Depth Worked	Horses		Rows		E.	Ad.	F.	E.
			No.	Av.Wt.	Width	Length				
1	10.	5.0 in.	2*	1300	3.5 ft.	80. rd.	3.0	12.8	.96	.350
2	11.	2.5 "	4*	1125	3.5 "	60.2 "	2.24	10.3	.95	.258
1	10.	4.0 "	2*	1200	3.6 "	55.5 "	2.36	7.75	.73	.208
1	11.	5.0 "	2*	1025	3.5 "	80. "	1.88	8.75	.97	.220
2	10.	2.5 "	4*	1050	3.5 "	80. "	3.0	12.2	.93	.338
1	10.	4.0 "	2*	1050	3.5 "	80. "	2.5	8.95	.82	.248
2	10.	5.0 "	4*	1050	3.5 "	60. "	2.25	5.85	.71	.194
2	11.	4.0 "	4	1075	3.5 "	42.4 "	1.99	8.26	.86	.207
2	10.	3.0 "	4	1100	3.6 "	160. "	3.0	11.1	.82	.298
3	10.	4.5 "	6	1200	3.5 "	70. "	2.18	7.65	.80	.211
3	11.	4.0 "	6	1200	3.5 "	41.6 "	2.79	9.35	.70	.236
1	10.	3.0 "	3	1150	7.0 "	80. "	2.14	17.2	.92	.238
2	10.	3.0 "	4*	1200	3.5 "	80. "	3.0	11.5	.87	.316
1	10.	3.0 "	2	1200	3.5 "	40. "	1.88	7.27	.88	.200
2	9.	3.5 "	4	1100	3.5 "	40. "	2.00	7.73	.97	.235
3	9.	3.5 "	6*	1200	3.6 "	80. "	2.00	5.63	.70	.169
2	10.	3.5 "	4*	1200	3.6 "	160. "	2.73	9.84	.80	.264
2	11.	3.5 "	4*	1100	3.6 "	80. "	2.5	9.08	.81	.245
1	11.	3.0 "	2	1200	3.6 "	80. "	2.5	9.47	.94	.285
1	11.	4.0 "	2*	1250	3.6 "	50. "	2.34	7.62	.72	.204

TABLE NO. X.

LISTING FOR CORN.

No. Men	H.	Depth Worked	Horses		Rows		V.	Ad.	F.	E.
			No.	Av.Wt	Width	Length				
1	10.	8. in.	3*	1100	3.5 ft.	79. rd.	2.47	5.75	.53	.159
1	9.	10. "	2	1100	3.5 "	95. "	2.0	6.85	.87	.210
2	12.	5. "	4*	1100	3.5 "	106. "	2.5	7.82	.60	.182
1	11.	6. "	3*	1050	3.3 "	80. "	2.5	9.65	.85	.258
1	10.	6. "	3	1000	3.5 "	80. "	3.0	10.00	.76	.275
2	10.	6. "	6	1100	3.5 "	80. "	2.0	8.0	.92	.223
1	11.	8. "	3	1200	3.5 "	47. "	1.7	5.5	.67	.138
1	10.5	6. "	3*	1100	3.5 "	80. "	2.5	10.0	.86	.260
2	10.	6. "	6*	1000	3.6 "	80. "	2.5	6.0	.53	.160
1	10.	5. "	3*	1100	3.5 "	80. "	2.5	9.0	.82	.248
2	10.	7. "	6*	1100	3/5 "	80. "	2.25	8.5	.78	.211
1	10.	6. "	3	1000	3.5 "	55. "	2.5	7.0	.64	.193
2	9.	10. "	6	1100	3.5 "	95. "	2.0	6.85	.53	.128

* Mule teams.

TABLE NO. XI.

CUTTING WHEAT.

No. Men	H.	Horses No.	Horses Av.Wt.	Width Worked	Length of Row	V.	Ad.	F.	E.
1	10.	4	1250	6. ft.	70. rds.	3.34	12.5	.50	.202
2	10.5	5	1100	7. "	80. "	3.0	15.4	.56	.203
1	11.	4	1250	7. "	80. "	3.0	16.6	.57	.207
2	10.	5*	1200	8. "	40. "	2.95	19.0	.64	,228
1	10.	4	1200	7. "	119. "	3.01	17.1	.74	.270
1	11.	4*	1300	7. "	80. "	3.0	21.6	.68	.247
1	10.	4*	1300	7. "	62. "	2.95	17.0	.66	.236
1	10.	4*	1300	8. "	120. "	2.38	19.3	.81	.193
1	10.	4*	1250	7. "	80. "	2.79	22.8	.93	.260
2	10.	6	1200	8. "	80. "	2.85	22.4	.79	.273
1	10.	4*	1300	7. "	80. "	2.0	15.56	.89	.216
1	10.	3	1300	7. "	30.3 "	3.08	19.5	.72	.262
1	11.	4	1200	7. "	80. "	2.14	10.01	.49	.127
1	11.	4*	1200	7. "	160. "	3.23	24.5	.79	.300
1	11.	4	1200	7. "	102. "	2.72	18.8	.64	.211
1	10.	4	1200	8. "	95. "	2.73	16.0	.59	.195
2	10.	5*	1200	7. "	50.8 "	2.08	12.32	.68	.165
1	10.	4*	1200	7. "	80. "	2.5	13.9	.64	.194
1	10.	4*	1200	8. "	80. "	2.5	15.85	.63	.190
1	10.	4	1250	6. "	80. "	3.0	18.3	.81	.294
2	11.	5	1350	7. "	80. "	2.55	20.8	.74	.228
1	11.	4*	1300	7. "	160. "	3.0	23.4	.81	.294
1	11.	4*	1300	8. "	160. "	3.0	26.9	.81	.294
1	11.	4	1300	7. "	80. "	2.53	20.6	.84	.247
1	11.	3	1200	7. "		2.14	18.8	.92	.238
1	11.	4	1200	7. "		4.0	18.0	.58	.211
2	10.	6*	1100	7. "		2.56	19.6	.87	.269
1	11.	4*	1100	7. "	145. "	1.98	16.95	.89	.213
1	10.	4*	1125	7. "		2.31	16.66	.82	.230
1	10.	4*	1300	8. "	160. "	2.43	17.6	.73	.214
2	11.	6*	1150	8. "		1.99	19.2	.88	.212
1	10.	6*	1200	8. "	80. "	2.5	19.4	.78	.236
2	10.	5	1150	7. "	80. "	2.5	20.0	.96	.291
1	10.	4	1200	7. "	42.7 "	2.66	13.9	.60	.194
1	10.5	4	1150	7. "	52. "	3.0	14.2	.52	.189
1	10.	4*	1050	8. "		2.5	12.3	.49	.149

* Mule Teams.

TABLE XII.

SHOWING ALL AVERAGES FROM ALL THE DIFFERENT TABLES OF V. AD, F. AND E. FOR THE DIFFERENT FARM OPERATIONS.

Operation.	Size of Machine	No. of teams	Average V.	Av.Ad.per 10 hr.day	Av. F.	Av. E.
Single Discing	7 ft.	9	2.55	15.73	.71	.222
Lap "	3.5 ft.	7	2.71	8.95	.80	.247
Sulky Plow	16 in.	6	2.42	3.33	.79	.243
Walker "	16 "	14	2.56	2.86	.69	.212
" "	14 "	6	2.5	2.67	.79	.230
Sulky "	14 "	4	2.5	2.54	.69	.271
Gang "	2-12 in.	22	2.56	4.71	.74	.246
Smoothing Harrow	10 ft.	14	2.45	20.13	.66	.198
Checkrow Planter	7 "	43	2.49	14.37	.66	.199
Drill "	7 "	12	2.52	15.17	.69	.213
Roller	7.5 "	19	2.62	19.33	.78	.244
1st Cultivation of Corn	3.5 "	47	2.04	7.15	.82	.200
2nd Cultivation of Corn	3.5 "	56	2.12	6.72	.76	.192
3rd Cultivation of Corn	3.5 "	23	2.34	8.07	.78	.221
4th Cultivation of Corn	3.5 "	19	2.43	8.78	.84	.241
Listing for Corn	3.5 "	18	2.32	7.63	.72	.203
Grain Binder	7 "	29	2.40	16.98	.73	.225
" "	8 "	13	2.58	18.67	.71	.218

DAILY DUTY OF FARM MACHINERY. Table 12 shows just what a man may be expected to do in a day. when working with any of the implements covered by these observations. Suppose you wish to know how many acres a man can single disc in a day with a 7 ft. disc; this table shows that while discing the average team walks 2.55 miles per hour and keeps going 71 percent of the time and covers 15.73 acres in 10 hours.

Suppose your disc is only 6 ft. wide and that you work 11 hours per day instead of 10 hours, how much can you do. The last column (E) shows the fraction of an acre that one foot in width of your disc will cover in one hour if your team goes 2.55 miles per hour and keeps going 71 percent of the time. E (the hour-foot efficiency) in this case is .222, then if your disc is 6 ft. wide in one hour you will do .222 X 6, or 1.332 acres, in 11 hours you will do 11 X 1.332 acres or 14.65 acres.

Suppose you must break 80 acres for corn, with a 16 in. sulky plow, how long will it take if you have a team of average ability. The above table shows that the average team (3 horses) to a 16 in. sulky plow plows 3.33 acres in 10 hours or .333 of an acre in one hour, then to plow 80 acres it would take $\frac{80}{.333}$ or 240.2 hours. Then if you work 9 hours per day 26.7 days; if you work 10 hours per day it will take approximately 24 days; or if you can work 11 hours per day it will take 21.83 or approximately 22 days.

To find the area your implement should cover in a day take the figure in the last column (E) of the table which cor-responds to your implement, multiiply the figure by the width of the implement for which you wish to find the area, which will give you the area your implement will cover in one hour, then if you multiply by the number of hours per working day you will get the area per day the implement will cover if you work an average team. To make this last example more clear, say you have an 8 ft. smoothing harrow what area per day may you be expected to cover if you work an average team. From the above table we find the average E for smoothing harrows is .198 (the area one foot in width covers in one hour). Then if your harrow is 8 ft. wide, your team walks 2.45 miles per hour and keeps going 66 percent of the time as the average team does, you will harrow 8 X .198, or 1.584 acres in one hour, or 15.84 acres per 10 hour day.

BREAKING 6.6 ACRES PER DAY 7 INCHES DEEP AT A COST OF .53¢ PER ACRE.

TABLE NO. XIII.

SHOWING THE RELATIVE EFFICIENCY OF MULES AND HORSES
WHILE PERFORMING ELEVEN OF THE ORDINARY FARM OPERATIONS.

Operation	No. Teams		Av. Wt.		Av. V.		Av. F.		Av. E.		*
	Mule	Horse	Mule	Horse	Mule	Horse	Mule	Horse	Mule	Horse	
Discing	10	17	1115	1103	2.69	2.46	.77	.73	.239	.221	8.14%
Breaking	30	23	1157	1134	2.69	2.32	.74	.74	.243	.211	15.17%
Harrowing	23	19	1077	1110	2.44	2.38	.70	.69	.209	.196	6.64%
Planting Corn	29	26	1147	1113	2.51	2.48	.68	.63	.214	.192	11.47
Rolling	4	16	1187	1128	2.81	2.49	.83	.76	.276	.224	23.2
1st Cult. of corn	49	35	1092	1134	2.12	1.84	.82	.79	.212	.178	19.1
2nd Cult. of corn	29	20	1143	1155	2.16	2.09	.77	.73	.199	.179	11.15
3rd Cult. of corn	29	9	1127	1185	2.26	2.17	.77	.81	.247	.215	14.9
4th Cult. of corn	20	15	1145	1153	2.57	2.18	.83	.86	.251	.238	5.35
Listing	10	8	1078	1191	2.46	2.2	.71	.73	.211	.194	8.76
Cutting Wheat	19	17	1214	1218	2.56	2.78	.76	.68	.228	.226	.88
TOTAL	225	205	1136	1132	2.42	2.32	.76	.72	.223	.203	11.34

* Higher efficiency of Mule teams.

TABLE NO. XIII.

HORSES VS. MULES AS FARM ANIMALS.--- This table shows that taken under any and all conditions of farm work that mules are more efficient farm work animals than are horses. Of course these figures do not show them to be uniformly more efficient throughout the different farm operations but with a total of 225 observations on mule teams and 205 for horse teams we find that for each operation mules are more efficient than horses; that on the average they not only walk faster in the harness but they keep moving a larger percent of the time. This latter fact is undoubtedly due to the fact that they either turn quicker or stand up better under more continued work.

TABLE NO. XIII A.

COST OF PLANTING AND TENDING CORN WITH MULES

COMPARED WITH THAT OF HORSES.

Operation	Av.Ad Mules	% Less,* Horses	Av.Ad Horses	Cost Per A.		Saved Per day by Mules.
				Mules	Horses	
Discing	11.99	8.14%	11.00	$ .29	$ .32	$ .36
Breaking	4.13	15.17	3.50	.73	.86	.54
Harrowing	19.03	6.64	17.80	.16	.18	.38
Planting	15.44	11.47	13.50	.16	.18	.31
Rolling	22.62	23.20	15.35	.11	.16	1.13
Cultivating	8.18	12.62	7.14	.31	.35	.33

* This figure is taken from the above Table No. XIII where it appears as higher efficiency of mule teams and used here as lower efficiency of horse teams.

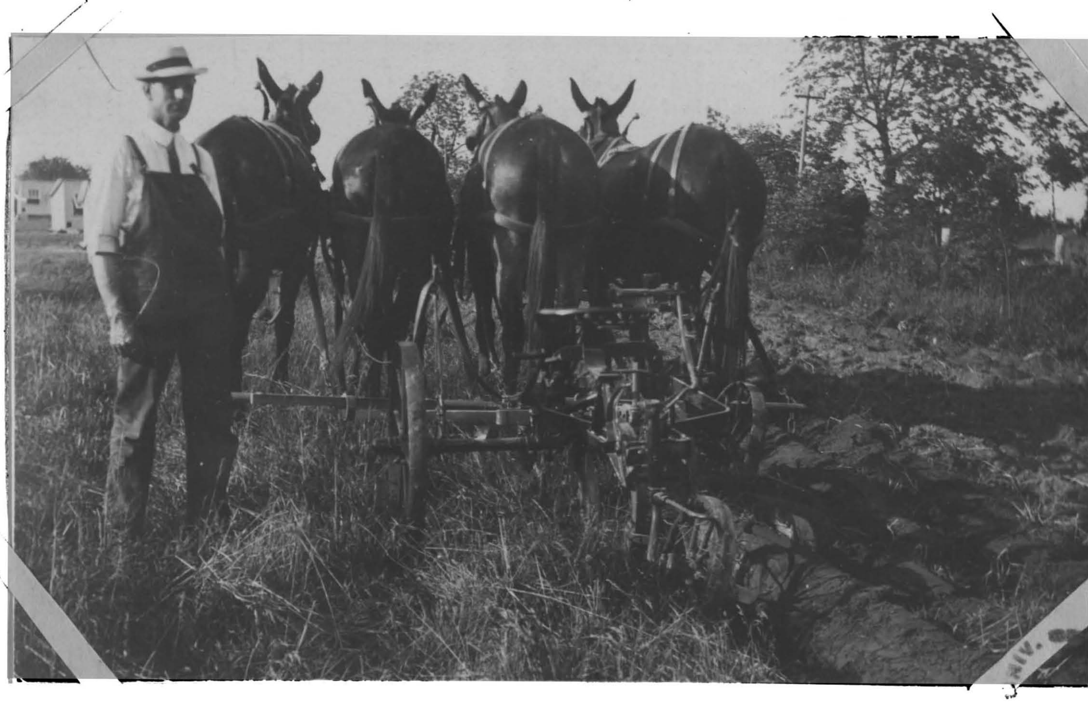
According to Table I3A it costs $2.69 per acre to grow corn with mule teams and $3.I0 per acre with horse teams, or a saving of .4I ¢ per acre by using mule teams. On an 80 acre corn crop this saving would be $32.80. This is a saving of I3 percent merely ffom the standpoint of labor and it is a generally accepted idea that mules may be fed cheaper than horses. Mr. O. R. Johnson of the Farm Management Department, Missouri Agricultural College has collected feeding records from actual feeding upon farms which show that mules may be fed 20 percent cheaper than horses. This gives a saving of I3 percent in efficiency and 20 percent on feed, or a total saving of 33 percent. This makes it nearly one third cheaper to grow corn with mules than it is with horses.

TABLE NO. XIV.

SHOWING THE RELATION BETWEEN THE LENGTH OF ROW AND THE COST OF OPERATION IN PLANTING AND TENDING CORN WITH BOTH MULES AND HORSES.

Operation	Length of Row : Rods	No. Teams	Av. V.	Av. Ad.	Av. F.	Av. E.	Cost per Acre.*
Listing	65 or less	2	2.10	6.0	.65	.165	.42
	66 to 90.	8	2.17	7.25	.67	.173	.34
	Over 90.	3	2.46	8.19	.75	.224	.30
Planting	65 or less	16	1.70	13.29	.60	.180	.19
	66 to 90.	30	2.48	14.89	.68	.204	.17
	Over 90.	10	2.48	15.54	.73	.216	.16
Rolling	65 or less	1	2.52	18.90	.75	.230	.13
	66 to 90.	14	2.63	19.09	.76	.243	.13
	Over 90.	4	2.61	19.35	.84	.254	.13
First Cultivation	65 or less	20	1.70	6.19	.77	.115	.40
	66 to 90.	40	2.13	7.16	.78	.180	.35
	Over 90.	23	2.17	7.67	.83	.210	.33
Second Cultivation	65 or less	14	1.95	6.05	.71	.166	.41
	66 to 90.	32	2.09	6.47	.73	.188	.39
	Over 90.	16	2.22	7.17	.76	.191	.35
Third Cultivation	65 or less	11	2.05	6.62	.73	.184	.38
	66 to 90.	19	2.52	8.80	.78	.235	.28
	Over 90.	7	2.53	8.92	.79	.243	.28
Fourth Cultivation	65 or less	8	2.23	7.22	.81	.218	.35
	66 to 90.	9	2.41	7.93	.81	.252	.31
	Over 90.	2	2.86	10.47	.87	.281	.24

* This cost was obtained by assuming a change of 10 ¢ per hour for team labor and 15 ¢ per hour for man labor, or 25 ¢ per hour for 10 hour day.



MULES AND THE GANG -- A highly profitable combination in preparing ground for corn.

LENGTH OF ROW. As the length of row increases the velocity of the team, the average area per day, the percent of time in actual operation and the hour-foot efficiency of the machine increases in direct ratio. From table No. XV we can readily figure the importance of the length of row upon the cost of production: For example, let us assume that for convenience of using the pasture we decide to put in a cross fence in a 40 acre field making two 20 acre fields. Then if both fields are to be planted to corn each of the 40 acres must bear the following charges more than would prevail if the fence was out of the way: Listing .12 ¢, planting .03 ¢, cultivating .17 ¢, or a total additional expense of .32 ¢ per acre on 40 acres equals to $12.80 that it will cost to turn at that cross fence during the production of one corn crop.

If we have a ditch, upon which we must turn, extending three-fourths across a similar field the cost will be as follows: ¾ of 40 acres equals 30 acres, times .32 ¢ (the additional cost per acre) equals $9.60 extra charge which must be made against that field for each year that it is in corn, so long as the ditch must be turned upon, besides the area which can not be cultivated because of the ditch.

A straw stack 66 feet square in a 40 acre field would increase the cost of tending the crop .32 ¢ per acre on two acres or .64 ¢ and if it is left 3 years as they often are it will cost $1.82 to turn upon it during that time besides the non-productive area upon which it stands.

TABLE NO. XV.

SHOWING THE RELATION BETWEEN THE VELOCITY OF THE TEAM AND THE COST PER ACRE OF PLANTING AND TENDING CORN AND CUTTING WHEAT.

Operation	V.	Av. Ad.	Av. F.	Av. E.	Cost per acre.
Listing	2.0 2.5 3.0	7.52 7.53 10.00	.78 .76 .76	.180 .200 .275	$ .33 .35 .25
Planting	2.0 2.5 3.0	12.36 15.49 17.37	.68 .67 .64	.151 .290 .226	.21 .16 .14
First cultivation	2.0 2.5 3.0	7.17 8.12 11.19	.83 .68 .92	.186 .225 .308	.35 .31 .22
Second cultivation	2.0 2.5 3.0	6.29 6.4 10.87	.80 .64 .69	.175 .192 .228	.40 .26 .23
Third cultivation	2.0 2.5 3.0	6.46 8.65 9.32	.78 .77 .79	.179 .236 .273	.39 .29 .27
Fourth cultivation	2.0 2.5 30	7.20 8.43 10.63	.83 .84 .81	.202 .244 .291	.35 .30 .24
Cutting wheat	2.0 2.5 3.0	14.34 17.90 17.99	.79 .75 .68	.195 .222 .241	.38 .31 .31

VELOCITY OF TEAM. Table 15 shows that by far the most important factor in determining the amount of work to be done in a day is the velocity with which the team travels. With each operation the area per day increases in a direct ratio as the velocity of the team increases. The efficiency of the workman, measured in terms of work done, is in direct ratio to the velocity of his team, notwithstanding the fact that the fraction of time actually in motion is in some cases in adverse ratio. Notice in the cases of planting corn and cutting wheat that as the velocity of the team increases the fraction of time in motion decreases but still the hour-foot efficiency of the machine increases. This would almost justify us in saying that on the average a farm laborer is just as good as the team he is working - a good workman working with a poor slow team is correspondingly poor even though he keeps them moving as much of the time as they are capable. An average workman does not materially raise the efficiency of a slow team but a good team with a rather high velocity will raise the efficiency of an average workman. On the average a certain amount of time is necessary to adjust the machine or implement, and ordinarily this factor would be the same for a team that walked 2 miles an hour as for one walking 3 miles an hour and it would be natural to expect that the team with the higher velocity might need to rest more often than the team that did not walk so fast, hence the inverse ratio between the velocity and fraction of time in motion.

but our data shows that in spite of the fact that they rest more, they have a much higher efficiency. The fraction of time the implement is kept moving has been attributed largely to the workman and taken as a measure of the efficiency of the workman. In extreme cases of course that would be true but this table shows that under average conditions the velocity of the team determines the efficiency of the workman and that the fraction of time in motion depends no more upon the efficiency of the workman than upon the ability of the team.

TABLE NO. XVI.

SHOWING THE RELATION BETWEEN THE SIZE AND TYPE OF MACHINE AND THE COST OF OPERATION.

Machine	Width of Machine	Horses	Av. V.	Av. F.	Av. Ad.	Cost Per A.
Single Disc	7 ft.	4	2.55	.71	15.73	.22
Double "	3.5 ft.	4	2.71	.80	8.95	.39
Sulky Plow	16 in.	3	2.42	.79	3.33	.91
Walker "	16 "	3	2.56	.69	2.86	1.05
Sulky "	14 "	2	2.50	.79	2.67	.94
Walker "	14 "	2	2.50	.69	2.54	.98
Gang "	24 "	4	2.56	.74	4.71	.74
Harrow	10 ft.	3	2.45	.66	20.13	.15
Checkrow Planter.	7 "	2	2.49	.66	14.37	.17
Drill Planter	7 "	2	2.52	.69	15.17	.16
Cultivator	3.5 "	2	2.18	.79	6.75	.37
Cultivator	7. "	3	2.36	.83	16.92	.18
Lister	3.5 "	3	2.32	.72	7.63	.39
Roller	7.5 "	2	2.62	.78	19.33	.13
Binder	7. "	4	2.58	.73	16.63	.21
"	8. "	4	2.64	.67	18.26	.19
"	8. "	5*	2.72	.71	19.20	.29

* With five horse teams an extra driver was used.

SIZE AND TYPE OF MACHINE AND THE COST OF OPERATION.

DISC.- Upon first thought we would perhaps expect a man to lap or double disc just one half as many acres per day as he would single disc, but table 16 does not justify the supposition. This table shows that the average team double discing does not only walk faster but keeps going a larger percent of the time than those single discing. This might lead us to think that the draft of the disc was lighter when double discing because half of the dirt being moved has been previously stirred.

BREAKING PLOWS - Table 16 shows that with a 16 in. sulky plow it costs .91 ¢ per acre to break ground while with the 16 in. walker plow it costs an average of $1.05 per acre. The teams to the walking plows have a higher average velocity than those to sulky plows have; then according to table 15 we would expect the walker plows to be more efficient but what happens. In this case the percent of time in motion is the dominating factor and the measure of the efficiency of the workman. The percent of time in actual operation is 79 for sulky plows and 69 for walker plows (both 14 and 16 in.). A decrease of 10 percent for walker plows which renders the sulky plows more efficient. Surely this condition can only be attributed to the inefficiency of the workman when walking behind the team - an argument in favor of seats on farm implements.

Notice too how much cheaper it is to break ground with a gang than with any of the other types of plows. The average cost per acre for breaking ground with walker plows is \$1.01-1/3, for sulky plows .92½ ¢, for the gang the cost per acre is only .74 ¢. The question often comes up in the management of a farm as to what kind of plows to buy and many farmers who have six head of work horses will buy two 16 in. plows, either both walkers or one sulky and a walker. This gives a cutting width of 32 in. when working full force; when two horses must be used for hauling, harrowing or planting corn a cutting width of 16 in. is left and one horse is generally idle. If a 24 in. gang and a 14 in. walker had been purchased the cutting width pulled by the six horses would be 38 in. and then when a two horse team was needed for purposes other than breaking, the gang plow could continue, with a cutting width of 24 in. If it becomes necessary to disc and plow at the same time the gang may be stopped and have four horses for the disc and two to plow, with a cutting width of 14 in. The logical divisions of teams is by pairs and not by threes.

CULTIVATORS- Table 16 shows that the cost per acre of cultivating corn is reduced more than 50 percent by the use of the two row cultivator over the single row cultivator; due to the fact that the working width is increased 50 percent with the added cost of only one horse which is more than offset by the fact that the three horses to the two row cultivators walk faster and keep going a larger percent of the time than the two horses to the one row cultivators.

They walk faster, perhaps because they are, on the average, better teams; a man with light teams does not usually buy a two row cultivator. Then again two row cultivators are generally used on the larger and more prosperous farms which generally have teams better than the average. They keep going a larger percent of the time in the first place perhaps because they are better teams and in the second place because the drivers of two row cultivators always ride while a large percent of the operators of one row cultivators walk.

TABLE NO. XVII.

SHOWING THE RELATION BETWEEN THE WEIGHT
OF TEAM (both mules and horses)
AND THE COST OF OPERATION.

Operation	Wt. of Teams	V.	Av. Ad.	Av. F.	Av. E.	Cost Per A
Discing (7 ft.)	950 to 1150 1155 to 1300	2.45 2.82	15.26 17.78	.74 .74	.218 .254	.23 .20
Breaking (16 in.)	950 to 1150 1155 to 1300	2.45 2.62	2.95 3.18	.73 .75	.222 .239	1.02 .94
Harrowing (10 ft.)	950 to 1150 1155 to 1300	2.41 2.43	20.03 20.09	.69 .73	.203 .209	.15 .15
Planting Corn (7 ft.)	950 to 1150 1155 to 1300	2.46 2.55	13.51 14.98	.65 .69	.193 .214	.19 .17
Rolling Corn (7.5 ft.)	950 to 1150 1155 to 1300	2.44 2.91	15.67 22.87	.73 .86	.209 .305	.16 .11
Cultivating Corn (3.5 ft.)	950 to 1150 1155 to 1300	2.18 2.32	7.28 7.38	.81 .82	.208 .211	.34 .33
Cutting Wheat (7 ft.)	950 to 1150 1155 to 1300	2.48 2.72	15.33 16.10	.74 .75	.219 .230	.23 .22

WEIGHT OF TEAMS - The above table shows that the heavier teams walk faster and keep going a larger percent of the time than the teams of lighter weight and thus have a higher efficiency. The largest difference in cost of operation is in the case of breaking ground which is perhaps the heaviest work of the ordinary farm operations.

TABLE NO. XVIII.

Showing the:-

Approximate limiting dates for performing field operations.

Average number of days (D) for performing field operations.

Proportion (P) of days actually available for field work.

Average daily duty (Ad) of field machinery.

Average seasonal duty (As.) of field machinery.

Operation.	Approximate limiting dates.	D. (days)	P. (days)	Ad. (acres)	As. (acres)
PREPARING GROUND FOR CORN	March 25, to May 9.	45.	2/3	2.70	81.0
Single discing		45.	2/3	15.73	
Double discing		45.	2/3	8.95	
Breaking		45.	2/3	-- --*	81.0
Harrowing		45.	2/3	20.13	
Planting	May 10, to 26	16.	5/8	14.77	147.7
Listing	May 10, to 26	16.	5/8	7.63	50.0
Planting	May 10, to 26	16.	5/8	14.77	
Rolling corn	May 9, to 25	15.	3/5	19.33	174.0
Cultivating corn	May 20, to July 2.	45.	5/9	6.75	42.0 †
Cutting Wheat					
7ft. Binder	June 20 to July 2.	12.	3/4	16.98	152.0
8ft. Binder		12.	3/4	18.67	168.0

* The area per day in this case would depend on the size and type of plow used. The seasonal figure here is based upon the use of a 12in. gang.

† One row cultivator.

SEASONAL DUTY OF FIELD MACHINERY.

In estimating the equipment needed for a given farm it is necessary to know what area a given machine or implement may be expected to cover during the whole period available for a particular class of work with that machine. This will vary greatly with the weather and other disturbing factors hence we can at best deal only with average conditions; but when these averages have been ascertained one can calculate, with a fair degree of accuracy, the amount of work a machine may be expected to do in actual practice.

The area a given machine or implement may be expected to cover per season depends upon the area covered covered per day and the number of days in the season within which the machine may be used for a particular operation. So in order to know the seasonal duty of field machinery we must know:

I. The area per day (Ad) that the machine or implement may be expected to cover in actual practice.

2. The number of days (D) in the period within which that particular operation must be done.

3. The proportion (P) of these days actually available for work; that is,the proportion of days in period D not lost by reason of rain,sundays, etc..

Suppose we wish to know how many acres of corn one man can cultivate four times during the average season available for the cultivation of corn. Our data shows that with a one row cultivator one man can plow 6.75 acres of corn per day and that there are 45 days in the period within which the work must be done and that 5/9 of these days are actually available for work. Then our formula for this problem would be $\frac{4}{6.75}$ equal 5/9 X 45. From this we find that the area per season is 42.; which means that one man with a team of average ability could tend 42. acres of corn.

Assuming that corn ground is to be double disced, plowed, harrowed twice and planted; how many acres can one man prepare and plant to corn during the season available for such work on the ordinary farm in the spring? Our data shows that there are 45 days in the period within which the ground must be prepared and that 2/3 of this time is actually available for work. For planting there are I6 days in the period within which the work must be done, 5/8 of which are actually available for work. A days work at double discing is 8.95 acres; breaking with a gang plow, 4.7I acres; harrowing 20.I3 acres; and planting, I4.77 acres. Hence to double disc, break harrow twice and plant one acre will require*--

$$\left(\frac{I}{8.95} + \frac{I}{4.7I} + \frac{2}{20.I3} + \frac{I}{I4.77}\right) \text{ days.}$$

For the area per season our formula will be --

$$As.\left(\frac{I}{8.95} + \frac{I}{4.7I} + \frac{2}{20.I3} + \frac{I}{I4.77}\right) \text{ equal } \left(2/3 \text{ X } 45\right) + \left(5/8 \text{ X } I6.\right)$$

From this equasion we find that As. equals 8I. That is, one man can prepare and plant 8I acres of corn from about March 25, to May 26. At first thought this figure would perhaps seem too high since the average farmer does not prepare and plant so many acres to corn; but on most Missouri farms a part of this season is devoted to the sowing of oats and the acreage of oats sown would correspondingly decrease the number of acres that could be prepared and planted to corn.

Suppose that the crop rotation calls for equal areas of oats and corn and that the oat ground is to be double disced harrowed and once and drilled and that a days work at drilling is I0 acres; how many acres of oats and corn can one man plant during the season available for such work. For this problem our formula becomes--

$$\text{As.}\left[\left(\frac{I}{8.95}+\frac{I}{20I3}+\frac{I}{I0}\right)+\left(\frac{I}{8.95}+\frac{I}{4.7I}+\frac{2}{20.I3}+\frac{I}{I4.77}\right)\right] \text{equals}$$

$2/3 \times 45 + 5/8 \times I6$. From this equasion we find that As. is equal to 53; which means that one man can plant 53 acres of each of corn and oats from March 25, to May 26. If the corn ground is to be listed and planted as is the general practice in some sections of Missouri, our formula would be--

$$\text{As.}\left[\left(\frac{I}{8.95}+\frac{I}{20.I3}+\frac{I}{I0}\right)+\left(\frac{I}{7.63}+\frac{I}{I4.77}\right)\right] \text{equals} \left(2/3 \times 45\right)+\left(5/8 \times I6.\right)$$

From this equasion we find that As. equals 87 acres; which means that one can plant 87. acres each of corn and oats if the oat ground is to be double disced, harrowed and planted; the corn ground listed and planted.

From the above figures it is evident that a man can prepare the ground and plant more corn in the spring than it will be possible for him to tend during the season available for tending corn. The limiting factor as to the sized corn crop one man can handle is the amount he can cultivate; hence the problem is to grow some crops as oats, cow peas etc, that can be planted in the season with corn but will not conflict with the corn as to the cultivating season.

Since the number of acres of corn one man can grow is limited by the area he can cultivate it is readily seen that if we are to grow a larger acreage of corn we must adopt a more efficient means of cultivation thah the one row cultivator. With a two row cultivator one man can cultivate I05 acres, then if a farmer is to grow as much corn as he can prepare the ground for and plant (8I acres) he must either hire another man and buy another single row cultivator or purchase a two row cultivator and do the cultivation himself. Even if a suitable man may be obtained during the cultivating season the cost of tending 8I acres of corn with two single row cultivators would be $II9.88, while to cultivate the same area with a two row cultivator would cost but $58.32 or a saving of $6I.56 by the use of a two row cultivator on an 8I acre corn crop. Now the question comes up as to how many acres of corn must a man grow to justify him in buying a two row cultivator. A single row cultivator with a seat for riding costs about $25. while a two row cultivator costs about $45. or a difference of $20. on the original investment. Figuring interest at 6% and depreciation at I0% we get I6% of $20. or $3.20 per year more that it costs to own a two row cultivator than it does to own a single row cultivator. Now if the two row cultivator saves .I9 cents on every acre cultivated it will take as many acres as I9 is contained in 3.20, or I7 acres to pay the extra cost of atwo row cultivator. Thus it appears that in cultivating I7 acres of corn it would be just as cheap to do it with a single as a two row cultivator, but on each acre above I7 one would save .I9 cents per acre by the use of a two row cultivator. This would perhaps not hold true in actual practice because the two row cultivator would be at more or less of a disadvantage working in such small fields but on a basis of 20 acre fields it surely would be profitable to use the two row cultivator. You do not consider efficiency of implement

The question of how many acres of grain must one grow to justify in owning a binder may be worked out as above. An ordinary grain binder costs about $I25. ; interest at 6% and depreciation I0% on this amount would be n$20. per year that it will cost to own a grain binder. The machine alone can be hired for .40 cents per acre. Then if we divide 20. by .40¢ we get 50. which means that 50 acres of grain must be cut to pay for owning a binder a year; on each additional acre above 50 acres would be a saving of 40¢ per acre by owning the binder. Thus it appears that if a farmers rotation calls for 50 acres of grain to be cut with a binder it would be just as cheap to hire a machine at 40¢ per acre as to own one. In fact it would be cheaper to hire the machine than to shed it for the rest of the year; but it is not always possible to hire a machine just at the time it is most needed and much loss may result from a few days delay. A group of farmers in a neighborhood who are growing small areas of grain might profitably own a binder in partnership. As shown by table I8 the seasonal duty of a binder is I52 acres of wheat, and if equal areas of wheat and oats are to be grown the seasonal duty of the binder may be doubled. Thus six farmers growing equal areas of wheat and oats, on a 25 acre basis, might own a binder in partnership and reasonably expect to get their grain cut in due time. If special attention is given to the time of seeding the crop and the variety of seed used, the time of ripening could be controlled so that the harvesting could be done on each of the six farms with one machine at just about the proper time.